National Aeronautics and Space Administration

ASK The Academy
Volume 4
Anthology

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Chapter 1

Messages from the Academy Director

Creating the Story

January 31, 2011 — Vol. 4, Issue 1

Your job is the story.

If you're skeptical about that assertion, consider its source. Bran Ferren, the former president of research and development of Walt Disney Imagineering, told me this ten years ago. Ferren also added that unless an organization operates with that conviction, it's going to be a failure. This was in the early days of our knowledge sharing forums, before we created *ASK Magazine* as a venue for practitioners to tell their stories. The conversations I had that day taught me that if the Academy was going to increase its impact on the agency, I needed to have the right people sharing the right stories.

Flight Director Gene Kranz (foreground) and Dr. Christopher Kraft (background) in the Mission Control Center in Houston, Texas, during the Gemini 5 flight. Photo Credit: NASA

A decade later, I heard a professor at the University of Houston propose that stories are just data with a soul. In an agency so immersed in and reliant on data, her remark resonated with my belief in the power that story, folklore, and myth hold over organizations. Much of NASA's folklore pertains to high expectations and an "elite-team" mentality. Stories range from Gene Kranz wearing a new vest for each mission to the piece of paper in project manager Dennis McCarthy's wallet with the initials BP written on it. (Be professional, proved, practical, and protective of the people and the hardware, and to persevere).

The reality of NASA projects is that there is rarely a clear-cut line between good and evil, right and wrong; rather we face conflicts between good and better, right and less right. It is the human element in all of its fickleness and resilience that adds the most depth to any story. If you proactively seek advice and have a modicum of luck, there will be people who will help you along the way. In a project, your progress often will be hindered. Practitioner stories tell us in a meaningful way that managing successful projects is about capitalizing on chance when it presents itself and persevering when it doesn't.

This may seem a simplistic, fanciful view, but I believe there is something to be gained from it. J.R.R Tolkien's famous *Fellowship of the Ring* managed a portfolio of quests that saved mankind and brought peace to Middle Earth. Our NASA workforce manages a portfolio of projects ultimately designed to uncover secrets of the universe, develop innovative technologies to better our lives, and open up scientific discovery to the world. Our version of project reality may not translate into a blockbuster trilogy, but we share a similar story. We just wear different costumes.

Everything we do at NASA is a story. In 2010, some of NASA's stories included the tenth anniversary of continuous habitation of the International Space Station, the results of LCROSS's attempts to find water on the moon, the first flight for NASA's Commercial Orbital Transportation

Services (COTS) program, and the agency's technical assistance in the rescue of 33 Chilean miners in Argentina, among others. Simply listing these does not do these tales proper justice. All were the result of individuals, teams, and organizations working together with sound engineering and project management practices. And the end results alone are not everything. Understanding why these stories had these endings is what matters.

In 2011, we are heading into unknown, unmarked waters. More than ever it is important for our organization to be artful and steadfast, our teams adaptive and innovative, and our individuals nimble and inspired. I have always believed that serendipity comes to those who are prepared for it. The Academy is dedicated to preparing NASA's workforce to meet today's needs and anticipate tomorrow's so that the agency can continue to thrive in a rapidly changing world.

Trends in Project Management

February 28, 2011 — Vol. 4, Issue 2

Three trends are shaping the future of project management, requiring a more global mindset from practitioners.

Our reality is one of constant change. Throughout the past year, I have seen organizations, leaders, and managers wrestle with challenges brought on by economic, political, technological, and organizational change. The complexity of the global economy continued to present surprises. Political powers shifted. E-books outsold paperbacks for the first time in history. Organizations like British Petroleum and Johnson & Johnson faced greater public scrutiny and accountability than ever before. All of this leads me to believe that organizations with open and global mindsets will gain the inside track in the project world. Three trends in particular stand out today.

Transparency

Projects exist in a more transparent, networked environment than in the past. In part, this is a function of policy. President Obama's **Open Government Directive** initiated a shift towards government transparency. Thirty-nine government agencies, including **NASA**, developed open government initiatives. World Wide Web pioneer Tim Berners-Lee highlighted the work of DATA.GOV, introducing the possibilities (and controversy) that open data and ideas can offer, from new uses of satellite data to provide relief to earthquake victims in Haiti to WikiLeaks. Managers and leaders are expected to be open about the work that they do. Information and decisions are no longer easily hidden behind the curtain. The jig is up—the public knows where to find the wizard.

Frugal Innovation

The growing demand for breakthrough technologies in engineering and management has brought on the emergence of innovation grounded by cost. Often associated with products like the Nokia 1100 and the Tata Nano, this innovation paradigm is spreading to aerospace projects like **LCROSS**, **cubesats**, and Johnson Space Center's **Project M**. It is time to realize that the next big thing will come from incremental changes punctuated by revolutionary leaps; it is a continuous process. *Homo Sapiens* didn't walk out of the primordial soup.

Smart Networks

Today's projects are about collaboration, alliances, and teaming—you're only as good as your network. In 1965, the launch of the world's first communications satellite introduced the "frightening prospect" of man being able to communicate anything anywhere in the world. Now organizational wikis, Facebook, Twitter, and blog-like platforms are rapidly spreading and transforming the way we connect and communicate. While these systems offer multiple ways to transfer knowledge and information, organizations need to harness these platforms' power. Cultivating "smart networks" that provide broad streams of information, a global perspective, and a sophisticated ability to manage information overload is integral to success.

Tomorrow's project world will be driven by an integrated and nearly invisible game-like framework that will enhance virtual work, connect distributed teams, and encourage collaborative discovery. This will act as a unifying medium for the next generation of young professionals, almost all of whom will work intensively with international partners. Today's project world is driven by participation and collaboration. We live in a society that expects to know about and believe in the work that we are doing—we owe them nothing less.

The Changing Knowledge Landscape

May 10, 2011 — Vol. 4, Issue 3

Effective knowledge sharing strategies bridge the gap between what and who.

A few weeks ago, I kept receiving an error message on my home computer. Baffled by this problem, I typed the message into my search engine to see if others had encountered it. Sure enough, my search returned a few thousand hits. I scanned the list, picked the one that appeared closest to my problem, and dove in. The first page didn't yield a useful answer, so I looked at another, and then another. The third was a bulletin board where another user had faced the same problem and asked the community for help. I read through the back and forth of dialogue: What are your settings? Have you tried this? No help. Other ideas? How about this? The solution at the bottom of the page—the one that worked for the user who had received the same error message—also worked for me. Problem solved.

That's an everyday use of the database approach to knowledge sharing. We have discrete, relatively simple problems, and we look for answers. It's more than information gathering, which is what we do when we search the web for a zip code; a better analogy is a cookbook, where we're looking for proven knowledge about the right steps to follow in an orderly sequence. The identity of the person who supplied the answer is not very important because the consequences of a wrong answer are relatively low. If the solution doesn't work, the consequence is most likely that you'll try another web page for a different answer. There's always the possibility that an answer could leave you worse off (for instance, if you download a software patch that contains a virus), and that's where common sense and judgment come into play. We search for an answer until we find the right one.

At the other end of the spectrum are complex problems that can't be solved by the cookbook approach. How does a NASA program manager learn about the realities of securing funding over several budget cycles? In this kind of knowledge sharing, the who is as important as the what. For example, Tom Moser's perspective on what it took to maintain political support for the Space Shuttle Program during its long development cycle is credible because of his experience as the deputy associate administrator for space flight during that time. An academic expert who studied NASA history might also come up with a convincing narrative on this topic, though it would lack the immediacy of Moser's version. A present-day program manager looking for insights would distinguish between the perspective of the reflective practitioner and the objective third-party analyst, making judgments about the biases and blind spots inherent in each (e.g., the organizational and cultural changes since Moser's time and the detachment of the academic analysis). Neither point of view would offer a complete answer to the program manager's challenges; both could provide critical insights.

In other words, as the complexity of the problems we face increases, the context and individuals are inextricable from the knowledge at stake. When we learn in this way, we ask ourselves two questions. The first is "Who is this person?" Only after we've answered that do we consider, "What is he or she saying?" And we make judgments about the person's character, context, and worldview as we interpret what he or she is saying. Knowledge in organizations does not exist independent of the people who possess it. As Larry Prusak said at our Knowledge Forum in April, knowledge without values, judgment, and wisdom is essentially technical skill. It's absolutely necessary, but it only goes so far in addressing the one-of-a-kind challenges that NASA faces every day.

Learning from Others in the Project World

June 14, 2011 — Vol. 4, Issue 4

A common refrain from very experienced practitioners at NASA is, "You're never as smart as you think you are."

NASA's mission has always enabled the agency to attract a highly talented workforce. We have world-class experts in any number of technical disciplines, and many at NASA have worked on programs or projects that are truly the "first and only" in a field. This can lead us to hold ourselves in high self-regard. "Nobody else in the history of humanity has ever done what we do," we tell each other. "We must be unique."

Since we're smart, we try to stay on our guard and not get too comfortable. We've known stories about the dangers of hubris—we're aware that past success cannot inoculate us against failures in the present. And yet we can't let go of the thought that things are different for us. Nobody else does space exploration like we do.

The truth is that large, complex projects in any number of sectors have lots of commonalities. Many are firsts and onlies, from the world's largest laser to the world's deepest oil well. Many fail to deliver within 125 percent of baseline cost (the threshold for a "critical breach" of the Nunn-McCurdy Act for Department of Defense programs), which often leads to schedule setbacks as well. And many exist in highly politicized contexts where everything from funding to environmental concerns can derail progress. In short, we're not alone.

Over the years, the Academy has brought practitioners from other sectors to NASA so we can learn from them. We work closely with the Project Management Institute (PMI), the world's largest professional organization dedicated to project management. We have invited participants from organizations ranging from the Department of Defense to the Brazilian oil giant Petrobras to share lessons with us. Since 2010 we've been part of the International Project Management Committee, a group that includes space agencies, industry partners, professional associations, and others interested in sharing best practices in project management. We've also learned from practitioners in sectors far from aerospace, such as pharmaceuticals, finance, and entertainment. Though the particulars of our respective businesses are different, we share a common organizing principle: the basic unit of work is the project.

The result has been a network of practitioners around the globe who help us benchmark our own efforts, identify our strengths and gaps, and inspire us to do better. We learn as much from colleagues at the Shell Project Academy, for example, as we do from others in the aerospace industry because the problems of workforce development in a project world are fundamentally common. When we step back from the specifics of our industry and sector, we see more similarities than differences. There is a lot we can learn from each other.

Learning in a Time of Transition

July 20, 2011 — Vol. 4, Issue 5

As we adjust to life after the space shuttle, we face new learning challenges for new missions.

We have known this day was coming for a long time.

The retirement of the space shuttle is a momentous change for NASA, and it's also a deeply personal issue. For most of us

Space shuttle Atlantis is seen over the Bahamas prior to a perfect docking with the International Space Station at 10:07 a.m. (CDT). Part of a Russian Progress spacecraft which is docked to the station is in the foreground. Credit: NASA

at NASA today, the shuttle is inseparable from our conception of human spaceflight. As I wrote in **ASK 37**, the shuttle has shaped the agency's mission, organization, and self-image for thirty years. The emotion surrounding the launch of STS-135 is something I will carry with me forever. It was a triumph tinged with sadness about what we are leaving behind.

At the same time, it is incredibly energizing to realize that even as we find it hard to fathom human spaceflight after the shuttle, the future will bring possibilities that we can't yet imagine. After Apollo-Soyuz marked the end of the Apollo program in 1975, nobody knew what the shuttle held in store for us. The signature accomplishments that we now celebrate – the Hubble servicing missions, the construction of the space station – were far off in the distance. There were setbacks and painful losses along the way as well. And yet we persevered, learned, and grew, both as an agency and as a space-faring nation.

The good news is that the American public still expresses strong support for space exploration. A recent **poll by Pew Research Center** found that nearly six in ten Americans (58%) say it's essential for the United States to continue being a world leader in space exploration. At the same time, polls by Pew and others show that the top public concerns today are about the economy and jobs. It's critical that we understand this reality.

The next generation of human spaceflight transportation systems will come online in a world that's very different than the one that shaped the context for the shuttle in 1981. First, we're living in a time of highly constrained government resources, and we should not anticipate that this will change anytime soon. Cost will be a paramount concern for all new systems.

This panoramic view was photographed from the International Space Station toward Earth, looking past space shuttle Atlantis' docked cargo bay and part of the station, including a solar array panel. The photo was taken as the joint complex passed over the southern hemisphere. Aurora Australis or the Southern Lights can be seen on Earth's horizon and a number of stars also are visible. Credit: NASA

A related issue is the way we work with the private sector. New models for procuring commercial space services are sure to change the way NASA does business. Contract management, acquisition strategy, and effective insight and oversight will only grow in importance.

Third, there has been a globalization of space exploration. At the time of STS-1, only a handful of nations had ever sent an astronaut into space. The space shuttle helped to change that. International cooperation is now central to our approach to human spaceflight. Between the International Space Station and our reliance on the Soyuz for the next few years, we have entered a wholly collaborative paradigm.

Finally, NASA faces a "gray-green" divide in its workforce. The average workforce age is 47, but the distribution is not even. There are lots of veterans with decades of experience, and there's a new generation of young professionals, but there are relatively few mid-career professionals in between to bridge the gap.

The Academy is working to address all these trends through its professional development activities. Our efforts to promote learning together with international partners and to meet the needs of young professionals across the agency are particularly important right now. Our future in human spaceflight will depend on smart networks that span government, industry, academia, and international partners. As with the shuttle, the success of our next generation of space transportation systems will depend first and foremost on people.

Blessing from the Godfather

August 30, 2011 — Vol. 4, Issue 6

Organizations that intend to succeed can't only rely on established experience. They have to allow for the creation of it.

Some of the most dangerous people in an organization are those who don't care about what they do. They only see the short term, what's best for them, and prevent others from growing and innovating. If you love your work, believe in the mission, and want the organization to thrive, you will see—if you haven't already—that your success depends entirely on other people.

With the graying of today's aerospace workforce, I have heard an increasing number of conversations about the need for mentoring. NASA truly is an organization based on relationships, and it has always had a strong mentoring culture. Tradition says that if you're old and you've been around a long time, it's time for you to share what you know. Pick a young person, sit them down in your office, chat with them, and point them in the right direction. For many, this is the way to mentor. I disagree. I would argue we sometimes disregard other types of mentoring because it doesn't look like what we expected it to.

Walking into NASA as a twenty-something from Brooklyn with a psychology degree, I was a horse of a different color, to say the least. **Frank Hoban**, my boss and mentor, was someone who could come off as intimidating. I loved that about him. He didn't direct me every step of the way. Instead, he created opportunities. I see this as an essential function of a mentor. As Facebook CIO Tim Campos remarked at the **2011 NASA IT Summit**, his early career success hinged on having opportunities to put his knowledge into action. "There were people who bet I could figure it out."

Frank invited me into his world, introduced me to his network, and involved me in his conversations and arguments. He believed in me. It was like getting a blessing from the godfather.

That simple act gave me confidence to step out of my office and talk to, connect with, and challenge people. He put me in situations where I could apply and then amplify my skills, knowledge, and passion for the work. Sure, I did stupid things occasionally—and he'd tell me—but then he'd help me recover and learn from those experiences.

Now, nearly three decades later, I find myself in Frank's position. Often it is the next generation we focus on because, quite frankly, they have more time to put our knowledge and experiences to use. But I've learned that mentoring happens at any age. I learn just as much from an early-career

This picture of a crescent-shaped Earth and Moon — the first of its kind ever taken by a spacecraft — was recorded Sept. 18, 1977, by NASA's Voyager 2 when it was 7.25 million miles (11.66 million kilometers) from Earth. Voyager 2 was launched on Aug. 20, 1977, 16 days before its twin, Voyager 1. Photo Credit: NASA employee as she or he does from me—maybe more. I would also caution against limiting the concept of mentoring to a one-on-one activity. Good mentoring is an integrated group activity and you never know how one act will propagate through an organization to create synergies. For all of our formal performance and aptitude metrics, the organization will select, develop, and nurture the people it wants to grow. At its core, I see developing the next generation as being about creating bridges between people and unleashing them to go and do great things.

Mentoring is a function of the mentee. While mentors are responsible for understanding what sort of mentor they are and making themselves available, mentees need to seek mentors out and be proactive about soliciting guidance. If I could ask Frank what made our mentoring relationship successful, he'd answer "Ed." From his standpoint, his job was to shape, challenge, and facilitate my growth. Like Tim Campos's mentors, Frank saw something in me and bet I would figure it out. So I went off and did the rest with his blessing.

Risk and Values

September 28, 2011 — Vol. 4, Issue 7

What does risk have to do with values? Everything, it turns out.

In the space business we tend to talk about risk in project management terms: cost, schedule, and technical. We have highly sophisticated tools such as probabilistic risk assessments (PRA) that help us quantify and interpret risks with as much precision as possible. These tools are critical as we wrestle with the difficulties of designing, building, and operating complex systems, particularly when human lives are at stake.

At the end of the day, though, tools don't make decisions—people do. Our engineering culture strives to make that process as objective and empirical as possible. We demand high fidelity data, and we have rigorous reviews that operate under a governance model that strives to give everyone a voice in making the case for or against key decisions. All this is also critical.

On Saturday, Aug. 27, 2011, International Space Station astronaut Ron Garan used a high definition camera to film one of the sixteen sunrises astronauts see each day. This image shows the rising sun as the station flew along a path between Rio de Janeiro, Brazil and Buenos Aires, Argentina. Photo Credit: NASA

At a certain point, though, our reliance on data and process can only take us so far. (If that weren't true, we could wrap our decisions into algorithms and let machines crank them out.) Once we get there, what are we left with? In short, our knowledge and our values. Our knowledge manifests itself as engineering judgment. We draw conclusions based on the specifics of the case at hand, the logic and persuasiveness of our colleagues' arguments, analogies to past experience (i.e., lessons learned), and the things we care about deeply. That's where values come into play.

NASA has four core values—safety, excellence, integrity, and teamwork—all of which are indispensable to making sound decisions about risks. Even so, when we're in the heat of considering a thorny issue, it's hard to step back and ask ourselves, "Does this honor safety as a value? Does it meet NASA's standard of excellence? Am I being an honest broker of ideas and information? Am I being a team player?" There are inherent tensions in living our values. Taking an unpopular stand sometimes feels like the opposite of being a team player. The safest spacecraft is the one that never launches. Perfect is the enemy of the good. Reflective practitioners acknowledge these tensions openly and do their best to navigate these ambiguities as they arise. Above all, they listen to the considered opinions of their colleagues and challenge their own assumptions, asking what-if questions of themselves before coming to conclusions.

Living our values on our programs and projects is like navigating by the stars; there's no GPS system that delivers precise guidance. When we're making decisions, our values are what we fall back on when we've exhausted everything else. They're not prescriptive, but if we keep them in mind we'll never lose sight of true north.

The Appeal of Space

October 28, 2011 — Vol. 4, Issue 8

The first International Astronautical Congress (IAC) held on the African continent was a potent reminder that nations seek the benefits of space for many different reasons.

At an event commemorating the 40th anniversary of Apollo 8, former mission commander Frank Borman said, "The reason we went to the Moon on Apollo 8 was to beat the Russians."

I was reminded of Borman's words while I spoke with Dr. Peter Martinez of South Africa and Dr. Adigun Abiodun of Nigeria during a special Masters with Masters event at the IAC. Both had to blaze their own career paths in aerospace because there were not well-trod paths to follow in their respective countries; neither country had the capability to put a rocket into orbit. The odds were against them, but each persevered.

This swirling landscape of stars is known as the North America Nebula. In visible light, the region resembles North America, but in this image infrared view from NASA's Spitzer Space Telescope, the continent disappears. Photo Credit: NASA

They were initially drawn to space by different motivations. Peter said he considered himself "one of the products of Apollo"—he was inspired by astronauts like Boreman. Ade was an engineer with expertise in hydrology whose interest stemmed from the potential of space applications—he was interested in learning what role satellites could play in understanding water resources in Nigeria. Both went on to work extensively with the United Nations' Committee on the Peaceful Uses of Outer Space (COPUOS), with Ade even serving as its chairman for a time.

The aspirations they hold for their countries in space are rooted in practical benefits. In the United States, on the other hand, we periodically engage in public debate about the merits of space exploration as a national priority. If we're no longer trying to beat the Russians (to paraphrase Borman), some ask if space exploration is still worth the cost when there are many competing priorities for public expenditures. Peter and Ade did not talk about space exploration as an abstract concept. Each want their people to reap the benefits that more mature space-faring nations take for granted.

A common theme at IAC among individuals I met from emerging space-faring nations was the need to build local capability in space. Many said they do not want to continue relying on existing space powers; they want their own engineers and their own facilities. An educated workforce builds broader capability within an economy that leads to the ability to improve society.

In a time of transition and uncertainty at NASA, it's easy to lose sight of the big picture. Peter and Ade reminded me that space's power to inspire goes hand in hand with its power to improve the lives of millions in ways that many of us take for granted at this point. We can learn from them.

Focus and Flexibility

November 29, 2011 — Vol. 4, Issue 9

The paradox of project execution is that it requires both single-minded focus and the flexibility to change course when needed.

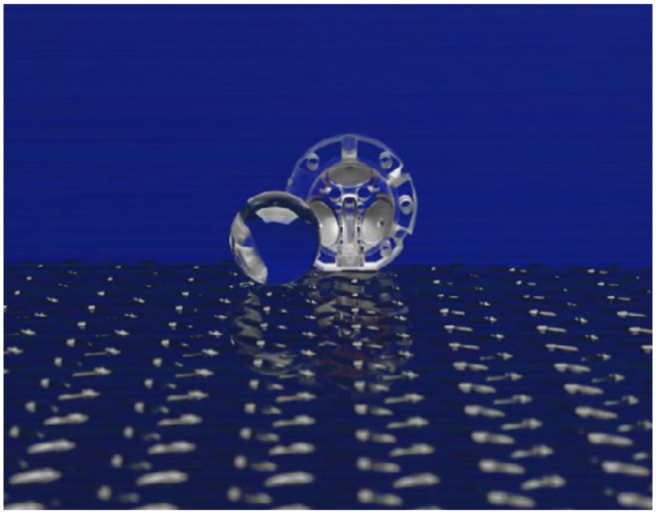


Image of an uncoated quartz rotor and half a housing on a sheet of diamond- plate steel. Photo Credit: Stanford University/Gravity Probe B

The longest-running project in NASA history was Gravity Probe B (GP-B), which first received agency funding in 1963 and launched in 2004. If that's all you know, it sounds like something went terribly wrong if the project lasted more than 40 years. The real story is much more interesting and complicated.

GP-B set out to confirm to key predictions of Einstein's theory of general relativity. In order to do so, it required significant technology development. If you think back to the state of the art in 1963, the United States and the Soviets had launched a relative handful of satellites and manned missions. The payloads for those first weather and Earth-observing satellites were primitive by today's standards. (If you visit the Air and Space Museum, you can see that the cabins for the Mercury missions were pretty low-tech too.) The GP-B experiment required precision measurements that were simply not yet possible in space. The first several years of the project were spent developing a relativity gyroscope experiment. Scientists and engineers learned a great deal about how spacecraft functioned in the space environment, and ultimately this technology development effort paid off: by the time GP-B launched, its star tracker and gyroscopes were the most precise ever designed and produced.

In its early years, GP-B operated on relatively low levels of funding, and it was kept alive (and rescued from cancellation) any number of times by personal appeals to Congress from Francis Everitt, its Principal Investigator at Stanford University. Its fortunes also depended on changes in policy at NASA. When the agency moved all science payloads on to the space shuttle and discontinued the use of expendable launch vehicles, GP-B's mission design called for an experiment to be carried out on two shuttle launches. After the *Challenger* accident, GP-B, along with other science missions in development, had to find another path to space.

In the mid-1980s NASA also tried what Administrator James Beggs called "the management experiment," naming Stanford University as the prime contractor for GP-B. The early management team at Stanford had significant technical experience, but not a lot of experience managing NASA flight projects. As the technology matured, NASA brought the project back in-house at Marshall Space Flight Center in the late 1990s to ensure that it had the proper degree of management oversight as it began the path to a launch date.

After a last-minute delay that uncovered significant technical risk, GP-B launched in April 2004. Seven years later, the final results from the experiment confirmed that Francis Everitt's experiment had succeeded in confirming Einstein's predictions.

GP-B exemplifies the paradox of being flexible and focused at the same time. It changed direction countless times over forty-one years, but the main objective—testing Einstein's predictions—remained the singular focus. In an increasingly unpredictable economic and political context, it's a survival skill.

Chapter 2

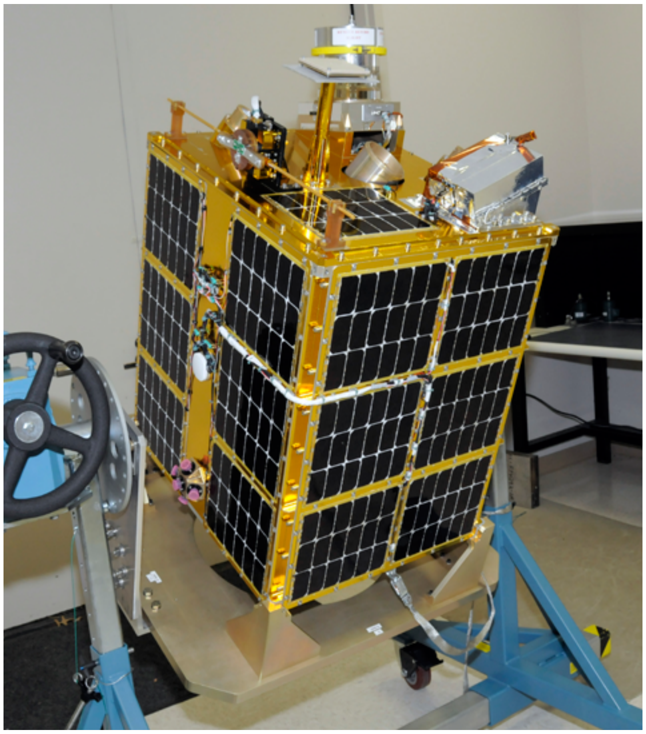
Academy Briefs

The SELDP Year from Three Perspectives

January 31, 2011 — Vol. 4, Issue 1

There's no clear path to become a top systems engineer, but as three engineers experienced, learning on the job is an important part of the process.

The Systems Engineering Leadership Development Program (SELDP) provides opportunities for a small class of high-potential candidates to develop and improve their systems engineering leadership skills and technical capabilities. A core feature of this yearlong program is a hands-on developmental assignment. These experiences, which take place away from a participant's home center, lead to a broader understanding of NASA and expand his or her systems engineering experience.



The FASTSAT-HSV01 spacecraft designed to carry multiple experiments to low-Earth orbit. Photo Credit: NASA

ASK the Academy tracked three members of the 2009-2010 SELDP class throughout the year as they adapted to the challenge of working and learning in a new setting.

Learning Every Day

"Fast" is the word that best describes Tom Simon's SELDP experience working at Marshall Space Flight Center (MSFC) on the **Fast, Affordable, Science and Technology SATellite (FASTSAT),** a microsatellite designed to carry six small experiments into space. Having served as a subsystems engineer at Johnson Space Center since 2001, Simon went from a program with thousands of employees to a project so small that everyone on the team could stand around the satellite.

Coming from eight years in the space shuttle program, the difference in scale was a learning experience. "If I had a question about how we mate to the launch vehicle with the satellite, I know exactly who to talk to," he said. "The family size of the project allowed the advantages of a co-located R&D effort even when we applied it to the development of a spacecraft."

FASTSAT also operated completely differently than the systems that Simon was accustomed to working with. "There were almost no moving parts, and no fluid systems," said Simon, who spent most of his career working on mechanical and fluid systems. He found himself troubleshooting electrical problems and software bugs. "The day-to-day work was in technical disciplines, which forced me to grow."

As the new kid on the block, Simon found that his colleagues were glad to help him get up to speed. "Even though I wasn't coming in on the same page that they were on, I tried to make it very clear that I cared about the success of the program," he said. "As long as that connection is made, folks don't mind helping you catch up--especially if they see you as someone who can help them too."

The schedule also represented a new way of working for Simon. FASTSAT had a 12-month project lifecycle. Processes were streamlined to where decisions were made in weeks, not months. "Most of the projects that I've worked on I've had intended launch dates a few or several years away," said Simon.

Working under such a fast-paced schedule shifted his approach to projects. "Every project I join now I'm going to start with the perspective of 'What do we need to do?' and not necessarily 'What have we always done?'" he said. "I'll never be the same again."

To keep pace with the schedule, testing took place nearly every day. "We had to basically get to the test phase earlier than any of us usually get to [it], and let the data speak for itself," Simon said. During the thermal vacuum test, the team was reviewing the output signal from the flight transceiver when they noticed a discrepancy that likely would have led to a failure. "One thing I learned from this project is that even if you're trying to do things affordably and quickly, you don't skip these meat-and-potatoes tests," he said. "We could have spent six months analyzing the system, and we never would have found the transceiver issue. Instead, in a few days of testing, we found it."

As the project wrapped up and awaited launch, Simon authored a lessons learned document for the team. He saw it as a resource for future work at NASA's manned spaceflight centers. "Once the Shuttle is retired and the Station is complete, there are going to be a lot of people working on systems that need to be approached differently than the way we've worked in the past," he said.

Working on FASTSAT helped Simon fill a gap in his experience between working on the Shuttle and R&D work earlier in his career in a lab setting. "I don't think they (the SELDP team) could have picked a better assignment, team, or organization for me," he said. "If the first 10 years are any sign, I'll be learning every day until I retire."

Leading from the Middle

Cynthia Hernandez knew the SELDP year demanded that she remained focused on meeting the goals she'd set for herself in the program. As a software engineer from Johnson Space Center, she enjoyed the challenge of working on an aeronautics flight project when she became the Deputy Chief Engineer of the **F-18 research program** at Dryden Flight Research Center. "Coming from a human space flight program, it's very rare that you actually get to see the hardware you're working on," she said. The F-18 project met her SELDP job assignment goals, but it did not address her leadership goal, which called for her to lead a team.

Hernandez sought the guidance of her SELDP support team, and ultimately reached a decision to seek a new assignment. Stephen Jensen, the SELDP Advocate at Dryden and Chief Engineer of the **Stratospheric Observatory For Infrared Astronomy (SOFIA)**, an aircraft-based observatory, and he identified a need within his own project that would enable Hernandez to meet her goal.

In March 2010, she joined SOFIA as it approached its final stages of integration and testing before its first test flight. Hernandez's job was to lead the Observatory Validation and Verification (V&V) Working Group, a 10-person team with responsibility for developing the V&V test procedures and executing the tests properly. "It was my responsibility to organize and develop the team, help them work together, and help each other out to accomplish our tasks," she said.

"I have a lot to learn in such a short period of time" said Hernandez at the beginning of her work on SOFIA. In addition to having never formed or led a team before, she had to bring together a diverse group, including senior engineers and scientists from Ames Research Center, the Germany Aerospace Center (DLR), Deutsches SOFIA Institute (DSI), University Space Research Association, and Dryden, to agree on test procedures. She also had to coordinate the writing of procedures, another new experience, which meant finding someone with the necessary expertise even though she had a very limited network at Dryden. In short, she faced the challenge of learning to lead from the middle--the team was her responsibility, yet she had very little formal authority.

"They were each so busy trying to meet their own milestones," she said. "Initially it proved difficult to find people to write test procedures." She happened to read a test procedure from another group that she found particularly well written, and she asked her boss, the Chief Engineer of SOFIA, if he knew its author, Cathy Davis. When he indicated that he did know her, Hernandez said she wanted her on the team. "She really played a key role

The SOFIA airborne observatory's 2.5-meter infrared telescope peers out from its cavity in the SOFIA rear fuselage during nighttime line operations testing. Photo Credit: NASA in pulling the procedures together." Hernandez, Davis, and a small core team made sure that the right procedures were in place and that the team didn't waste time on unnecessary ones.

Hernandez ultimately led the team through a four-day observatory checkout process before scientists came aboard to do their own tests of the instruments. She then began work on the test plan for the 003-level (the highest level) of integration testing for the overall observatory. Shortly after her assignment ended, SOFIA achieved "first light" -- the observatory was successfully activated in flight.

Looking back on her assignment, Hernandez learned a great deal from the process of working across organizational and cultural boundaries. "Working with different cultures and different organizations gave me the opportunity to broaden my way of thinking and approach to solving problems," she said. As NASA's missions increasingly involve international partners in critical path activities, that lesson is likely to pay dividends many times over.

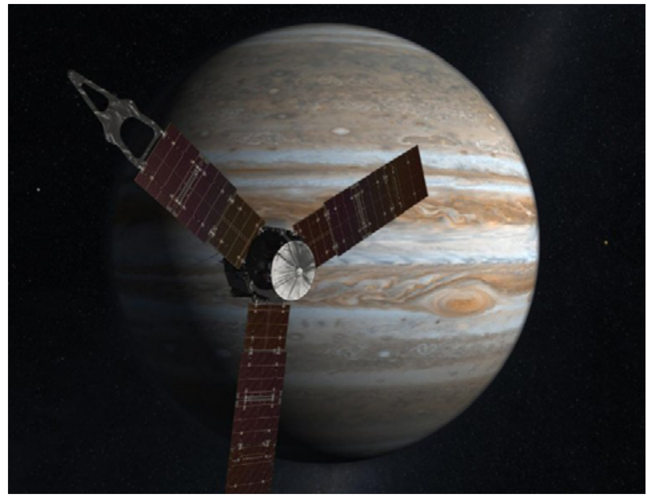
The Value of Constructive Paranoia

Going from aeronautics research at Langley Research Center to a large spaceflight project at the Jet Propulsion Laboratory (JPL), Michael Lightfoot felt like he had travelled to another planet. At JPL, the lexicon everyone used sounded familiar, only it carried a different meaning. Team members seemed to intuitively know what to do, like bees in a hive. "You don't know how they know what they're doing or what they're supposed to be doing, but it happens," he said.

His SELDP assignment brought him to the **Jupiter Uranus Neptune Outreach (Juno)** mission, a billion dollar international project. From the beginning, he took care to watch the people around the center to uncover the source of the invisible "playbook" that seemed to be ingrained in the team. "I've come to the conclusion that the processes, the rules, and the requirements serenade a point from which discussion can begin," he said, "but the real glue that holds it all together is the people."

Lightfoot, who spent a large portion of his assignment working on verification and validation (V&V), saw the value of "constructive paranoia," which kept the team on its toes. "No one wants a failure to happen while they're on deck, or at any time, so people are constantly looking for avenues to make improvements that actually aid the confidence that the spacecraft's going to do what they expect it to do." Certain people within the team picked up on concerns or issues, evaluated them, and generated detailed solutions or scenarios to determine how they would affect mission success--that is, focusing on the value of the science that would be collected.

For instance, the team realized that it could decrease ground control costs by putting the spacecraft into hibernation mode at times when it would not be collecting data. At the same time, they recognized that while this offered a savings in cost, it also posed the risk that the spacecraft might not awaken from its sleep mode. Solutions included developing



Artist concept of Juno spacecraft in front of Jupiter. With its suite of science instruments, Juno will map Jupiter's intense magnetic field, investigate the existence of a solid planetary core, measure the amount of water and ammonia in the deep atmosphere and observe the planet's auroras. Image Credit: NASA/Jet Propulsion Laboratory

a "phone home" capability if Juno ran into trouble, and also prompted debate concerning how such changes would affect the design of the spacecraft. Thinking about cost in this way, "forces people to think differently to come up with good alternative engineering solutions," he said. Lightfoot, who prior to this assignment was accustomed to developing an instrument that was then shipped off for installation elsewhere, appreciated the opportunity to participate in the system-level evaluation of a mission.

Lightfoot's overall understanding of systems engineering changed during his rotational assignment. "I thought I knew what it was when I went away," he said. "I got a more complex picture of what it could be at JPL." His key insight related to the high level of integration on most NASA projects today. "Some of the things we're taking on now are so highly coupled that if you try to decompose them and ship work off to traditional engineering disciplines, you run the possibility of locking in a design too early, and shooting yourself in the foot without knowing it."

His SELDP experience added another challenge to his day-to-day work as an evolving systems engineer. "It's hard to put the genie back in the bottle," he said about learning to work at the systems level. "I've seen a lot and there's an awful lot I want to share." He aims to share his experiences with his Langley and other agency coworkers to "make sure we put some things in place that enable us to sustain ourselves."

International Project Management Course

February 28, 2011 — Vol. 4, Issue 2

The Academy's "International Project Management" course featured participants from four continents and instructors from two of NASA's international partners.

Participants at APPEL's International Project Management course at Kennedy Space Center (2011). Photo Credit: NASA APPEL

As the importance of international collaboration has increased over the past several years, the Academy has undertaken new efforts, in close collaboration with the Office of International and Interagency Relations, to learn from and with NASA's international partners. As a founding member of the International Program/Project Management Committee (IPMC), the Academy asked fellow IPMC members to review the course materials for its "International Project Management" (IPM) course, with a view toward identifying common principles and practices that could be incorporated into the curriculum. Based on that feedback, the Academy revised the curriculum and invited international partners to participate in the most recent offering of IPM, which took place January 31 – February 4, 2011 at Kennedy Space Center.

Participants came from all NASA centers and Headquarters as well as the Canadian Space Agency (CSA), European Space Agency (ESA), German Aerospace Center (DLR), Japanese Aerospace Exploration Agency (JAXA), Korea Aerospace Research Institute (KARI) and four IPMC industry partners (Astrium, Thales Alenia, INVAP, and Comau). The course also featured partners serving as instructors, with Andreas Diekmann of ESA and Takayuki Imoto of JAXA offering perspectives from their respective agencies.

"This course represents a real change in the way we learn together," said Academy Director Dr. Ed Hoffman. "The ability to collaborate successfully is critical to NASA's present and future. Our workforce stands to gain a lot by understanding the challenges and opportunities of working with our international partners."

Masters with Masters on Sustainability

May 10, 2011 — Vol. 4, Issue 3

Leaders from NASA, the White House, and industry tackled the challenge of organizational sustainability.
While the issue of organizational sustainability is commonplace today, it wasn't always that way.

The eighth Masters with Masters event featured Olga Dominguez, NASA's assistant administrator for the **Office of Strategic Infrastructure,** Michelle Moore, Federal Environmental Executive with the **White House Council on Environmental Quality,** and **Dr. Brian Nattrass**, co-founder of Sustainability Partners and author of several books on sustainability. Academy Director Dr. Ed Hoffman moderated the conversation before a live audience at NASA Headquarters.

One of the key challenges of addressing organizational sustainability is communicating in the correct language, the guests agreed. "How do you get the importance of sustainability across to program and project managers?" Dominguez asked rhetorically. She went on to say that framing the issue in the language of NASA—risk to mission cost, schedule, and success—was critical to initiating a conversation about organizational sustainability.

Moore defined sustainability as a systems challenge, where solving for the whole and thinking across disciplines is critical to developing expertise in the field. "Being able to solve problems as systems challenges as opposed to silo challenges are two ideas that I really think you have to bring to the table," she said.

One measure of an organization's commitment to sustainability is the extent to which its strategic planning reflects those concerns, the practitioners agreed. "It is fundamental to support the work of the organization," said Nattrass. When he worked with the U.S. Army on a project, the customer made it very clear that its primary mission was to support the United States and its allies. He recalled the customer saying, "If you can show me how sustainability supports our mission, then we can be friends." It was that simple.

Ultimately, sustainability problems pose a multidisciplinary challenge. "One of the cool things about sustainability is that it really creates an opportunity for innovation,"

From left to right: NASA Academy Director Ed Hoffman hosted Dr. Brian Nattrass, co-founder of Sustainability Partners, Michelle Moore, Federal Environmental Executive for the White House Council on Environmental Quality, and Olga Dominguez, NASA's assistant administrator for the Office of Strategic Infrastructure, for the eighth Masters with Masters event. Credit: NASA said Dominguez. From green IT to telework to "green" spacecraft, the guests agreed that sustainability is becoming embedded in organizational practices at NASA and across the government.

2011 SELDP Class Graduates

July 20, 2011 — Vol. 4, Issue 5

"If you're not learning something, you're probably not stretching yourself as an engineer," NASA Administrator Charlie Bolden told the 2011 graduating class of the Systems Engineering Leadership Development Program (SELDP)
The 2011 SELDP class completed its yearlong program on June 15, 2011. In addition to completing a six-month rotational assignment at a new center on an unfamiliar project, participants also went through a series of interactive workshops that took them behind the scenes at organizations like Google and General Motors.

Each class member shared reflections from the year, with stories ranging from how they came to NASA, what they learned from their rotational assignments, and how they envision the future of systems engineering at NASA. "The world has great expectations of NASA," said Jane Oh, principal investigator and group supervisor at the Jet Propulsion Laboratory, who told how growing up in South Korea has shaped her work at NASA. "The world is looking to us to do the nearly impossible things."

Keynote speaker Dr. Antonio Elias, executive president and general manager for Advanced Programs at Orbital, shared the systems engineering story behind the development of the Pegasus rocket. Elias joined Orbital, which was then a 20-person company, in 1986. Tasked with developing a cost-effective way to access space, Elias became the systems engineer for the Pegasus rocket.

He highlighted two systems engineering decisions made during the Pegasus development: air launch and the launch aircraft. After the team couldn't acquire a ride for the Pegasus from the ground, the team looked at the B-52, SR-71, and Hercules as air launch vehicle possibilities before deciding on the B-52. "The Pegasus rocket was the largest thing ever dropped from a B-52," said Elias, who drew inspiration from the X-15 program's air launch approach.

The graduates of the 2011 SELDP class engage in a group activity at NASA Headquarters on June 15, 2011. Photo Credit: NASA APPEL

NASA Chief Engineer Mike Ryschkewitsch speaks to the graduates of the 2011 SELDP graduating class at NASA Headquarters on June 15, 2011. Photo Credit: NASA APPEL

Elias also shared the importance of systems engineering situation awareness. "I find a lot of analogies between the discipline of flying and a lot of the disciplines in systems engineering. There's one flying element that I'm going to [highlight] as perhaps the single most important aspect of systems engineering. In flying, it's called "situation awareness" or sometimes 'being ahead of the airplane'—knowing or feeling, intuiting what is going to happen so nothing surprises you," said Elias. "Situation awareness is probably the single most important element of systems engineering."

Elias's talk was punctuated by a visit from NASA Administrator Charlie Bolden, who congratulated the class and emphasized the connection between pushing boundaries and learning. "Don't be afraid to take measured risks," he said.

"NASA exists to reach new heights and reveal the unknown so what we do and learn will benefit all mankind," said Chief Engineer Mike Ryschkewitsch to the graduates. "What each of us do, no matter how small, it does make a difference. We are driven by being part of something bigger than ourselves and the opportunity to make a difference."

The class closed the day with a group activity followed by a ceremony and family gathering. "Most of us sign up to be better engineers," said Jose Matienzo, a member of the Space Launch System Program Office at Marshall Space Flight Center, "but you find out you become a better person."

Chapter 3

Academy Interviews

Jon Verville
The NASA Wiki Space

May 10, 2011 — Vol. 4, Issue 3

If you ever feel like a mad scientist who can produce game-changing inventions, but can't seem to find your wallet, a wiki may help you get things in order.

Jon Verville, an information-based software engineer and lead for the Applied Engineering and Technology Directorate (AETD) Wiki at Goddard Space Flight Center, is on a mission to find clever ways to push NASA's capability through sharing knowledge, data, and ideas across the organization. Prior to his wiki work, he was involved in the RF communication systems for LADEE, the SCaN Test Bed (CoNNeCT), the South Pole TDRSS Relay (SPTR), and served as the deputy communication systems lead on the Magnetosphere MultiScale mission.

Home page for the AETD Wiki at NASA's Goddard Space Flight Center. Image courtesy of Jon Verville.

ASK the Academy: You weren't always the Goddard "wiki guy." What sparked your interest in creating a wiki and knowledge management systems?

Jon Verville: That's a good question. Basically, I had some level of frustration with the information resources that were available when I was just starting my engineering career at Goddard. My first mentor, Dave Israel, was both a great mentor and a world-class communication systems engineer. My work and the challenges I faced were equally world-class in difficulty, and to find solutions to these challenges required very specialized data, information, and knowledge. One of the challenges was getting to relevant pre-existing paper and digital materials, which had been produced by Dave and the rest of my fellow communication systems engineers at Goddard, at the time when they were needed. Much of this useful information and knowledge was locked away in each engineer's own paper or digital file cabinet, or in an archived email, often buried very deeply. Specific things within this material weren't very easy to find, even for the engineer themselves! You pretty much go hunt for it on your own. However, as an early engineer at Goddard, I didn't even know what questions to ask or the context that would even be necessary to ask a question. That was a frustration for me. I don't think that this is unique to Goddard or NASA, but is something that is a problem for any large organization. The trick is organizations that address this problem in a unique way have an advantage. I saw this as an opportunity.

In a small attempt to address this, I started a wiki as a side project, just by installing the free software that powers Wikipedia. I began experimenting with it, slowly telling a few people about it here and there. Eventually, I really saw how it could work for us just by testing some simple ideas out and experimenting. One of the first things I did with this new wiki site was put together a table of all the spacecraft that our branch, the Microwave and Communication Systems Branch, had worked on, and included the technical specifications for each mission. Now this certainly did not require the use of a wiki, but the nice thing was that it now was in a central, discoverable place on our intranet and anyone in our group could update it. The table had columns such as: the radio manufacturer, antenna details, and the communication data rate of the spacecraft. Just creating this table and putting a point of contact for the communications engineer on that particular mission actually was a very quick and easy win. Since then it has expanded to over 500 technical wiki pages.

ATA: How did you gain leadership support to pursue this wiki initiative?

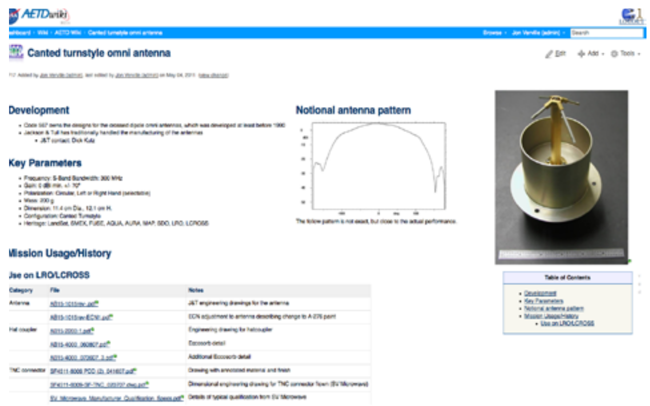
Verville: I've been very fortunate, actually, because at some level, I have been in the right place at the right time and had support from the right people. Back in 2009, I was on a committee that was tasked with giving our perspective of life within our engineering directorate at Goddard as it pertained to early career employees. We were asked for suggestions and advice, which we delivered to our Director of Engineering, who at the time was Orlando Figueroa, and his next level of management. We had a series of meetings with the directorate, and through the course of those meetings one of the things that came up as a topic was how we address knowledge transfer and knowledge capture for engineers within Goddard's engineering directorate.

Basically, I spoke up during the meeting and said, "Hey, I'm kind of working on this wiki as a side project and am trying to address that very problem. Is that something you guys would be interested in hearing about?" And they said, "Sure, let's do it." So I went and collected my thoughts on what I had learned from my wiki experiment and the other early career folks also on this committee and I organized the material and flushed out how that vision would look before I presented it.

I also took the time to meet with Orlando ahead of time to see what he was looking for. Essentially, I wanted my enthusiasm – our enthusiasm – to match up with the needs of the organization. I crafted the presentation and after all of that legwork, it was very well received. The director polled all of his direct reports and he asked them what they thought about the idea, and they jumped at it.

ATA: Tell us about the biggest challenge you face in trying to increase collaboration with a tool like this?

Verville: The biggest challenge by far is not technical. It's most definitely cultural. Just the simple idea of somebody being able to live edit something someone had created previously is such a foreign concept. We have this culture whereby you do what your boss tells you and you're graded against how well you did on what your boss told you to do. This kind of breaks that paradigm in a sense because it's really a proactive paradigm with each person finding a way to uniquely invest in the organization. In the end, that's what this is all about, everyone helping to invest in the organization so that when new engineers and scientists are coming into the organization they have that resource that I was looking for, but didn't have in my early career. I think that's a big challenge because you have to help the knowledge workers



Screenshot of the canted turn style omni antenna wiki page housed within the AETD Wiki at NASA's Goddard Space Flight Center..

in your organization to get past that because there's no direct model for it at some level. In NASA, we're used to working in a very document and email-centric world where someone owns a document from cradle to grave and people share updates and answers to questions through email to only who needs to know. New collaborative websites, such as wikis, have the potential to change this. It's not one person investing in an organization's knowledge, its democratizing it so that everyone has an easy way to contribute to that organization's knowledge. In a sense, we're asking, "How can you pay it forward?"

I found that a solution for this challenge is literally meeting people face to face and talking them through it. I do a lot of going out and talking, sharing what it is I'm doing and why I'm doing it, and teaching tutorials and such. This helps people dip their toe in the water, and from there it's easy to take the second step.

ATA: What are some examples of groups or organizations who have succeeded in using a wiki?

Verville: The majority of my examples are grassroots projects, which is telling of the way these things work. It's really hard to make these initiatives top-down and not bottom-up. There's one group here at Goddard that built an instrument that flew on STS-125. It was called the **Relative Navigation System**. This team based out of Goddard had to coordinate individuals at Glenn and Johnson. Since they were geographically dispersed, they used a wiki to document their system because it was very experimental. It was an experiment that was essentially trying to improve the state-of-the-art for robotic docking. The team used it for day to day operations and documenting their systems and the nuances, quirks, strengths, and limitations that they didn't know about previously. This team used it in a way that was really beneficial. It was only open to a small, closed group, but again, they didn't have support or even see the need to share outside of their group. But this is where I see the great use of a wiki and where they can be successful.

I have heard about or read about dozens of organizations where wikis have come and gone. These failures were because there wasn't a clear purpose. So, number one, have a clear purpose. Number two, communicate that purpose. Number three, weave that purpose into the organization's mission and figure out how the wiki can fit the ways the organization does business. Those are definitely three things that I spend a lot of my time doing.

Another example comes from before I even really got into wikis seriously, I was attending a conference and I bumped into Chris Rasmussen and some others who worked on Intellipedia, which is part of the system that the intelligence community put together. User adoption was very grassroots. They use it as an institutional resource. The wiki was added, I think, six years ago, and the system has thousands of active users and I think it has over a million edits.

They also have an award called "The Golden Spade," which is awarded to people who have contributed to the wiki significantly. It is a little, gold spray-painted shovel that is given to the individual or their supervisor and is used as a sort of incentive to reward that kind of behavior. (The spade is representative of wiki "gardening.")

ATA: You have an upcoming paper on the state of wiki practices at NASA. Can you give us a preview of what to expect?

Verville: There are many more stories beyond what I have told that I have discovered in my travels around the agency talking about these topics. In the paper we are going to be highlighting different wikis that have been used successful at NASA. They are sort of mini-case studies. They tell you some of the background, typical specs for what they have created, and then how they are encouraging adoption. We'll also touch on some of the reasoning and motivation behind collaborative engineering systems in general.

My collaborator, Dr. Patricia Jones from Ames and I are approaching this paper to spread the story of early wiki adopters across the agency. In the words of Tim O'Reilly, "The future is here. It's just not evenly distributed yet." We are just trying to distribute that future among folks so that if they get their hands on this paper they can have some insight into this organization and then maybe it'll give them a place to start.

Exit Interview with Bryan O'Connor

May 10, 2011 — Vol. 4, Issue 3

On his last day in the office, Bryan O'Connor, Chief of Safety and Mission Assurance, spoke with *ASK the Academy*.

Bryan O'Connor retired as Chief of Safety and Mission Assurance on August 31, 2011, after serving nearly a decade as NASA's top safety and mission assurance official. O'Connor is a former Marine Corps test pilot and aeronautical engineer, with more than 5,000 hours of flying time in over 40 types of aircraft. He joined the NASA astronaut program in 1980 and flew two space shuttle missions, serving as pilot on STS-61B in 1985 and commander of STS-40 in 1991.

ASK the Academy: You were a test pilot and a shuttle astronaut before becoming Chief of Safety and Mission Assurance, and your successor Terry Willcutt followed a similar career trajectory. Can you talk about how being a test pilot is good preparation for leading in safety and mission assurance?

Bryan O'Connor: As you mentioned, both of us have test pilot backgrounds, for about the same amount of time and from the same place. Different airplanes, but we came from Patuxent River Naval Air Test Center backgrounds. I think we learned there that you have to have a great deal of respect for the potential and kinetic energy of these things we strap on to ourselves. We spent an awful lot of time in planning for the flights we did. Operationally, there was always obviously planning for a mission. We were operational pilots. But when we went into the test world, the planning took a different slant to it. It was more about the test objectives. The actual airplane itself is the test objective, not delivering a weapon to a target.

There's an obvious safety piece that was a little different than what we had as operational pilots. We learned the difference between hard rules that you just cannot violate and rules that are the kind you challenge. An operational pilot knows that you're supposed to stay within the flight envelope of the aircraft. Don't go faster or higher than the aircraft is cleared for. But we were creating the envelope as test pilots, so we gained a great deal of respect for the idea of expanding an envelope, and all the test preparation and understanding of the aerodynamics and the engineering and the systems stuff that we had to know in order to go and rewrite, challenge, or change things that in the past had been inviolable rules. I think it was that learning that helped us appreciate the safety aspects of what we were doing when we came to NASA.

Astronauts Mary L. Cleve and Bryan D. O'Connor look toward the camera during an integrated simulation for the STS-6 mission. The two are at the spacecraft communicator (CAPCOM) console in the mission operations control room (MOCR) of the JSC mission control center. Photo Credit: NASA/JSC

Official portrait of Bryan D. O'Connor, United States Marine Corps (USMC) Colonel, member of Astronaut Class 9 (1980), and space shuttle commander. O'Connor wears a launch and entry suit (LES) with his helmet displayed on table in front of him. Photo Credit: NASA

ATA: What changes have you seen in the safety culture during your time at NASA?

BOC: Before the *Challenger* accident, the safety and mission assurance community and the safety culture in human spaceflight were what we'd inherited from the Apollo days. There was a substantial operational flavor to it. For those of us in the crew office, I remember one of the first lectures we heard as brand-newbies down there in Houston was the Apollo 13 story. Gene Krantz himself gathered us all around and spent about three hours talking about that flight, and what it meant to the human spaceflight community to have experienced the failure of the hardware and bringing back the crew alive, and how Apollo 13 was considered by folks in the Mission Operations world as right up there almost at the same level of success as Apollo 11 itself. The safety culture was just very much a piece of that story.

In later years I read about the British explorer Ernest Shackleton, who failed in his mission to explore the South Pole and Antarctica, but he got all 27 of his people back. He spent two years down there after his ship got stuck in the ice and then was crushed and sunk, and his men were standing on ice floes for all that time before they could finally get them back to England. It's the fact that he saved everybody that makes that story very compelling and unusual, and it has a special place in the hearts and minds of British people when they talk about their heroes. That was the same flavor of the Apollo 13 story. It really suggested that we like doing high-risk things, but we really like bringing the crew back alive afterward. So that was what I was introduced to in Houston.

The developmental aspects of systems safety engineering were there, but in retrospect they were not very well founded. They weren't accepted too much by the engineering community, and even thought there were safety, reliability, and quality engineers involved in the design, development, and test flying, it was almost as if they were checks in the box: "Did somebody remember to call them?" Their value statement was not as high as it subsequently became.

It was the learning from both the *Challenger* and the *Columbia* accidents that really helped to solidify the need for a capable and credible SR&QA (safety, reliability and quality assurance) workforce to help from Day 1 in the development activities of a new system. I hope that's the legacy of those mishaps, because there were strong words in both of those mishap reports about the safety organization. Where is it? What is it doing? Is it relevant? Do the things that the safety people do mean anything to the developers? I think today that as a (SR&QA) community, we're much more appreciated. They're (engineers and designers) actually asking for us to show up for their meetings because they don't want to start them without us. That's been a big change.

ATA: Along that same line, a couple years ago at an event at Goddard on organizational silence, you said that there has to be an institutional system in place that ensures that people speak up and bring relevant information forward. Do you think NASA has arrived at that point today?

BOC: There has been a lot of work done after *Columbia* accident investigation. The checks and balances were one of the big root cause discussions. There was a need to improve the standing of both the engineering and the SR&QA organization in the decision-making when there's residual risk, or safety matters especially. So, we explicitly wrote into our policy the requirement that all these people have a seat at the table, that they have mandatory votes where their authority calls for it. We've also instituted and put in writing for the first time the role of the risk-taker when we're talking about residual risk, and that's been very important.

I think of it as the four-legged stool: the technical authority owns the requirements, the safety and mission assurance authority decides whether the risk is acceptable or not, the risk-taker must volunteer to take the risk, and then and only then, when those three things have been done, can the program or project manager accept that risk. Those four roles have been stated in the highest documents for governance in the agency. It's flowing down — and in some places it was already there — for the decision-making for the high-risk work that we do, especially when there's safety involved.

Now having said that, I keep telling my people and the Center Directors around the agency that instituting that governance model in a set of words with a "shall" statement — "You shall have so and so governance model" — does not make it work. The only way it works is if you have good, credible, respected people with whom you have populated the various legs of that stool. You shouldn't just hire enough crewmembers to fly the space station missions and no more. You must have experienced crewmembers who are not currently flying but who are available to the next development activity as part of the development team, so that you can get the crew's look at residual risk areas, and have them in tune and involved enough so they understand what the risks are and can represent "The crew volunteers to take the risk" model that I talked about. I say this because there are people questioning how many crewmembers NASA needs, and why you need any more than what you're flying. This is an R&D activity, it's not just about flying.

When Terry (Willcutt) and I were at Pax (Patuxent) River, we spent a heck of a lot more time planning and participating in the development of the next aircraft or the next major mod to an aircraft with the designers and the developers than we did in the cockpit. We spent a tremendous amount of time in simulators and design sessions, and looking over hazard analysis reports, and giving the crew's input to the development as part of being a test pilot. That same thing applies here at NASA, and sometimes people forget that.

The same goes on the safety and mission assurance side. In the past we sometimes were criticized for not having capable people in our workforce, and folks might show up at a meeting and not be prepared or not understand the issue. Maybe we'd send a propulsion person from the safety organization when the subject was aerodynamics, and they weren't much help, and they didn't bother to go and ask for help because their staffing was very low in the home office. These are all problems that cannot be fixed by simply saying, "You have to have the safety office represented in the meeting." You have to fix these by having good, capable, credible people in those organizations with responsive home offices to back them up. This is the job of the Center Directors, by and large, and I credit them for putting really good people in our safety and mission assurance organizations over the years. In my opinion, NASA SMA is populated today with the best group that we've ever had at NASA.

ATA: You mentioned the legacy of the *Challenger* and *Columbia* accidents. What do you think is the most memorable contribution you've made in your time as Chief Safety Officer?

BOC: I don't know that I've personally made any contributions, because I tend to steal from other (smarter) people. (Laughs.) I am not very good at inventing things or coming out of nowhere with creative ideas, but I know a good one when I see it, and I'll steal it and benchmark and ask my guys to do something like it if we think it makes sense. Coaching and prodding is the mode that I've been using. The real work that's been done is by the folks in the trenches.

The requirements work that it takes to do this job at Headquarters is continuous. We often are criticized for having too many "shall" statements, and then the very next day we're criticized by others for not being standardized enough across the agency, which begs for more "shall" statements. Trying to drive that mission support function that we own in SR&QA down the middle of that road is tricky. We're not a bunch of Chicken Littles waving red flags every five minutes, and yet we're credible enough that when we do speak up, people will listen because they trust us. And that's the car I've been trying to drive, but I'm just steering. The folks who are in our divisions here and at the Safety Center and at the IV&V facility, and the safety and mission assurance directors at the centers with their people are the ones who get the credit for these changes over time.

ATA: What do you see as the biggest challenge on the horizon for safety and mission assurance?

BOC: Fighting complacency. I commonly tell our folks that there are two modes of mishap prevention. One mode is reacting to the last big accident, and the other mode is fighting complacency. Just about everything we do in the SR&QA world can fit into one of those two buckets. For example, the Launch Services Program has seen a couple of failures with the commercial Taurus XL rockets that they buy. They're reeling right now and trying to figure out how to prevent that in the future. Complacency is not anywhere to be seen in that community. They're reacting to the last mishap, and everything they're doing is to try to understand what happened and put things in place that will prevent similar failures in the future. That basically defines their entire workday, whereas in the human spaceflight world, we haven't had any failures in quite a while. Right now we've got a logistics issue with Russian rocket problems, but by and large since the *Columbia* accident there hasn't been a real human safety failure to speak of.

STS-40 Mission Specialist (MS) M. Rhea Seddon (left) and Commander Bryan D. O'Connor review the text and graphics system (TAGS) 15 ft long printout on the middeck of Columbia, Orbiter Vehicle (OV) 102. Photo Credit: NASA/JSC

There's a tendency — not necessarily of the people in the trenches — but we Washingtonians sometimes tend to forget the lessons because we haven't thought about them in a while, and we sometimes forget the tremendous amounts of energy involved, and the challenges posed by the environment and the human elements to our designs. Those things become a little bit past history, and unfortunately, what that feeds sometimes is complacency, and it shows up at all levels, including our stakeholders outside the agency. If it's been a while since our last failure, people who are looking to us to do great things sometimes forget how hard this work is to do. We start talking more about affordability than safety, and about getting the NASA oversight and insight down to very low levels because it's so expensive, without mentioning in the same sentence how important oversight and insight are to preventing mishaps. We even hear our astronauts being referred to as simply "biological cargo" by people who should know better. These are signs that we look for that we're in complacency mode, and of course it's natural for that environment to creep up on us. It's a real challenge for our community to fight that, and to remind each other that just because we haven't had a recent accident doesn't make this stuff easy.

ATA: What are your thoughts about the safety and mission assurance challenge ahead regarding the transition to commercial crew?

BOC: The S&MA challenge for commercial crew is trying to figure out where we fit in best, how to support the program in ensuring and assuring that when we do finally decide to put our people on top of these rockets, that we're not taking unnecessary risk. These are not NASA developments, per se. The concept designs are coming from the commercial people. We're experimenting with new ways to oversee that work with as few people as we can manage in order to meet the affordability goals. It's quite a big management experiment for us, and our folks are not comfortable with it, just as nobody is comfortable when they're getting into unknown territory. I think the big challenge that I hand off to Terry is, "Make sure that we're not doing something inappropriate here in pulling back or not having the visibility we need, or by not setting the table properly for our decision-makers to accept risk and to put our people on these rockets when they're relatively new and haven't been tested yet."

ATA: What advice do you have for young professionals entering the aerospace profession fresh out of college?

BOC: I'd tell them that when we hire a fresh-out, we do it because we like their technical potential, their education, and their energy, and we want them to help us go to the next levels in the agency. Because of that, when they see something they don't understand or that doesn't pass a sanity check in terms of a communication they're witnessing, it's OK for them to raise their hand and say something about it. This goes back to that concept of organizational silence. Sometimes our new people are intimated a little bit and they don't speak up, even when something doesn't smell right. We should encourage them to go ahead and do that. You don't want to overdo it of course, and have people being disruptive or educating themselves at the expense of everyone else who's trying to get something done. I know that can be overdone. But when I first showed up at the Johnson Space Center, they had a plaque over the wall in the Mission Ops control room that said something to the effect of, "In God We Trust — All Others Bring Data." That was quite intimidating to a new person, because between the lines it suggested that, "We not interested in your opinion on things. If you have data, we'll listen, but your opinion is not requested here."

A lot of us came to NASA after years of doing flight testing and R&D work and so on. After the *Challenger* accident, I really beat myself up for being too silent in the first few years that I was there, and I said to myself, "This agency isn't as smart as it thinks it is," to quote Tommy Holloway.

The idea of asking if you don't understand something — even if you want to go out in the hall and do it so you're not disruptive — that's fine. We hire good people to help us move forward, and asking questions is just part of that.

CHAPTER 4

Knowledge Briefs

ORBITING CARBON OBSERVATORY-2—UNFINISHED BUSINESS

May 10, 2011 — Vol. 4, Issue 3

OCO-2 demonstrates that there is a way to bounce back from failure and forge ahead with the mission.

On Tuesday, February 24, 2009, the **Orbiting Carbon Observatory (OCO)** launched into the sky aboard a Taurus XL rocket. Its mission was to measure carbon dioxide in the atmosphere globally. Ultimately it would provide a better understanding of Earth's carbon dioxide emitters and sinks. But the mission did not go according to plan when OCO left the ground.

"It was there one moment and then gone the next," said Ralph Basilio, then OCO deputy project manager. "We didn't have anything." OCO had missed its insertion orbit due to a mishap with a faulty launch vehicle payload fairing. The hardware that didn't burn up in the atmosphere splashed down in the Pacific Ocean near Antarctica. The next day, the OCO team returned to the Jet Propulsion Laboratory in Pasadena, California. "By the end of the day Friday [three days after launch], we had put together initial study results [for a replacement mission] and sent it off to NASA Headquarters," said Basilio.

NASA's Orbiting Carbon Observatory is on the launch pad at Vandenberg Air Force Base in California. Credit: Randy Beaudoin

There was no time to grieve. The OCO team shook it off and got to work. "We went from emotional shock to we need to roll up our sleeves and get the work done," said Basilio. The mission was that important.

Sleeves Up

In the six months that followed, the OCO team needed to formally establish the "why" and "how" of and Orbiting Carbon Observatory-2 (OCO-2) mission. Basilio, now the project manager of the proposed OCO-2 mission, and his team took a step back. An OCO science team established the "why": the scientific community simply cannot wait for a future mission. OCO's measurements were fundamental to future missions laid out in the **NASA's Earth Science Decadal Survey** designed to inform global climate change science and policy.

A team of engineers worked the "how." Options included: a direct rebuild of the original OCO; rebuild and improve on OCO; co-manifest an OCO-like instrument on another planned mission; put an OCO instrument on the International Space Station; or rebuild and co-manifest an OCO observatory on a shared launch vehicle. The team decided that a direct rebuild with necessary improvements was the best option given the mission risk profile and tight schedule.

In September 2009, NASA presented an almost "carbon copy" OCO-2 mission plan to the Office of Science and Technology Policy (OSTP) and the Office of Management and Budget (OMB). By early 2010, the OCO-2 team received Authority to Proceed (ATP). NASA assigned project management to JPL. Orbital Sciences Corporation was selected to rebuild the spacecraft and provide the Taurus-XL launch vehicle. OCO-2 has a 28-month development cycle from the ATP received at Key Decision Point C (KDP-C) to launch.

Challenges

One of the most daunting challenges for the OCO-2 team is the compressed schedule. OCO's original project lifecycle was 36 months long. OCO-2 has 28 months. Currently in Phase C, the team is building, assembling, and testing hardware. Getting to this point hasn't been easy.

OCO-2 went through a tailored formulation phase. Since OCO-2 is a near-replica of OCO, the project team was permitted to skip key decision points (KDP) A and B, and several other technical reviews. As a result, the formulation phase was only eight months long, rather than a more typical 21 months. They completed their Critical Design Review (CDR) in a single day in August 2010. "People said it couldn't be done," said Basilio. The OCO-2 team walked away with two action items, both of which were closed out on the second day during a splinter session. KDP-C followed a month later. Basilio, who worked on missions like Mars Pathfinder and Deep-Space 1, said that "a lot of those 'faster, better, cheaper' experiences that I had back then are helping me on OCO-2."

Schedule aside, the OCO-2 team also has had to face the reality of parts obsolescence. The original OCO design incorporated a few now obsolete instrument components, including a memory chip on the RAD6000 flight computer. The team also has had to account for long-lead parts, redesign certain components, or find certain components elsewhere. In the case of OCO's instrument cryocooler assembly, there wasn't a spare, and the team worked with the GOES-R project to acquire one.

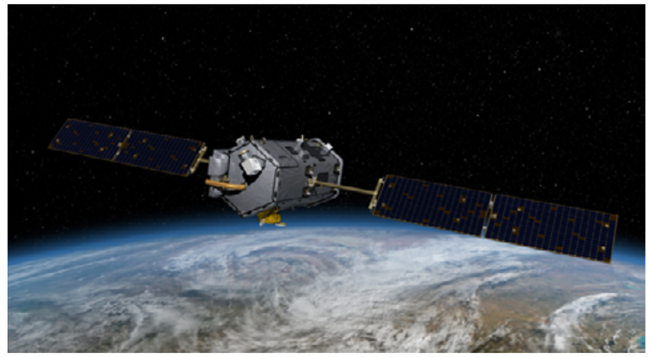
Heading into the summer, Basilio has identified one critical path item: an optical bench assembly. Described as "the heart of the instrument," the team has instituted corrective actions to catch the team back up over the next few weeks. Time remains the big driver. "We need to make sure that the product is correct and that we work only as quickly as proper caution permits," said Basilio. "Our big challenge is to make sure that we get to the launch site as scheduled."

OCO-2 is scheduled to launch in 2013, though the recent mishap with Glory, which bears similarities to the original OCO mission, has introduced new uncertainties.

On Learning

With a second chance to fly, the OCO-2 team is has a unique opportunity. "Instead of documenting lessons learned for potential incorporation into a future endeavor," said Basilio, "we have this opportunity to actually go ahead and employ those lessons learned." Ultimately, the OCO-2 team hopes to be able to measures how successful these lessons were to the success of the OCO-2 mission.

OCO-2's lessons are already making their way elsewhere. The Jason-3 project team sits four floors below the OCO-2 project team at JPL. "We have an opportunity to talk to each other once in a while," said Basilio, who also worked with the mission's project manager on Jason-2. "I try to provide him [the Jason-3 project manager] with as much information as I can to help him along." Basilio believes that this type of knowledge sharing is beneficial not only to the OCO-2 project, JPL, and NASA, but also to the American taxpayer in the long run.



Artist's concept of the Orbiting Carbon Observatory. Credit: NASA/JPL

The lessons and knowledge gained from OCO-2 will also be employed for a possible OCO-3 mission of opportunity and inform the Active Sensing of CO2 Emissions over Nights, Days, and Seasons (ASCENDS) mission. ASCENDS is a movement away from OCO's passive measurement system to an active measurement system. OCO's instrument looks at the spectra of reflected sunlight, ASCENDS is envisioned as an active laser system. "You can actually look at the carbon dioxide on the dark side [of Earth]," explained Basilio.

OCO, OCO-2, and the OCO-3 mission of opportunity are the evolutionary steps needed to get to ASCENDS. "We're hoping to use the experience that we've gained using a passive system to help us figure out how to enact an active laser system that will provide more precision, more accuracy in the future."

On People

After the failure of the first OCO mission, "coming to work every day was a little bit of a struggle, at least for me personally, because of the unknown," said Basilio. "A lot of us just couldn't wait until NASA Headquarters made the official decision to say 'OK, you guys are real, hit the ground running. Here are the resources that you need and make it happen. If you need any help, we're here to facilitate.'"

"One of the key strengths that we have is that we have a very, very good team," he added. "Not just here at JPL, not just internal to the project and with our industry partner, but the program office and NASA Headquarters." Managing relationships with all of the project stakeholders has been vital to OCO-2's promising progress.

"We lost OCO because of something we couldn't control," said Basilio. Now, taking on OCO-2 and its compressed schedule, Basilio said the stress is worth it. "For me, getting ready for launch and getting ready for mission operations has always been a high point." Basilio and his team take pride in giving the nation's decision-makers and public the information that they need so they can make informed decisions. "How could you want to avoid something like that?"

"We don't just come to work and punch a clock and walk away from it. If you really look at the folks at NASA, people are really dedicated to doing a good job – not just for the sake of the job, but because they believe in that endeavor." Basilio is proud to lead his 100-plus member team. "People are the critical component in any endeavor that we have at NASA," he said. "People are willing to work together for a common cause and that's really the thing that's going to carry us through."

Weathering Ike

May 10, 2011 — Vol. 4, Issue 3

Operating the International Space Station under normal circumstances is challenging. Doing it during the third costliest hurricane to hit the United States is another story.

Natural disasters here on earth are usually not the first performance-threatening obstacles to space exploration missions—budgets and technical problems are more frequent show-stoppers. On September 9, 2008, when Hurricane Ike was headed for Houston, it had been at least two decades since the last big storm hit Johnson Space Center (JSC). Ike was the third storm in four weeks to trigger an emergency response, compelling hurricane-fatigued area residents to evacuate or buckle down to ride out the storm. The last concern for most local residents was the International Space Station (ISS).

That was not the case at JSC, which was busy with operations and preparations for ongoing and future missions. NASA astronaut Greg Chamitoff was aboard the ISS on Expedition 17 with two cosmonauts, Progress and Soyuz vehicles were scheduled to dock and undock from the ISS in early September, and STS-125 was slated to launch October 8 for the final servicing mission of the Hubble Space Telescope.
Before Ike made landfall, a "Rideout" team was in place to maintain necessary operations within JSC, which includes Mission Control Center (MCC) for ISS. This meant maintaining vital servers and coordinating station operations. NASA Flight Directors Heather Rarick and Courtenay McMillan, along with their teams, were tasked with sustaining ISS operations from remote locations throughout the storm.

Picture of Hurricane Ike taken by the crew of the International Space Station flying 220 statute miles above Earth. Credit: NASA

A Four-Week Dress Rehearsal

Despite regularly rehearsing emergency response plans, chances to execute and learn from them are few and far between. Events like September 11, 2001, and Hurricane Lili in 2002 drove the development of improved backup plans in the event that ISS operations were jeopardized.

NASA mitigates the risk of losing ISS command and control in Houston through redundancy. A smaller version of mission control in Moscow serves as one backup, though its capability is limited by the use of ground-based satellites, which can only transmit data when the ISS flies over their antennae. The Backup Control Center (BCC) at Marshall Space Flight Center provides more functionality today, but it was still in the process of being configured in May 2008. Even with two backups, JSC seeks to avoid losing capability through Houston. "Once you swing away from Houston," said Rarick, "it takes a long time and effort to swing back."

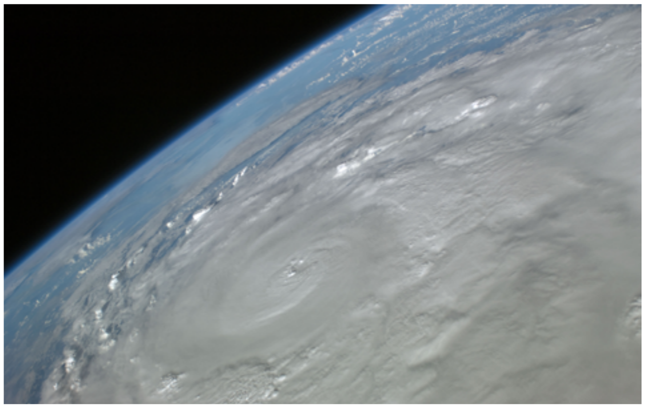
Enter the BCC Advisory Team (BAT), a mobile squad dispatched to undisclosed locations to carry out ISS operations. This team can quickly provide command and control capability if MCC is unable to do so. It was dispatched when Ike started on its path straight for Houston (twelve days after Hurricane Gustav, which arrived twenty days after tropical storm Edouard). In addition, McMillan flew to Marshall Space Flight Center (MSFC) to lead the BCC team. Rarick joined BAT outside of Austin, Texas, to provide plans and data that were already in progress to support the current astronaut team on ISS (Expedition 17) and overall ISS systems status and plans. "Once BAT is operational, then we just sit and wait until all MCC operations in Houston are handed over to BAT," said Rarick.

*No, no! Don't shut **that** one down.*

BAT set up their mobile mission control in a small hotel conference room. Two digital clocks, labeled "GMT" and "CST" with yellow Post-It notes, were at the front of the room. Outside, parents, children, and pets lined the hotel halls, seeking refuge from the storm. None would have guessed what this team was doing.

The first half hour of every morning was rough. "At 8:00 a.m., the hotel guests would get up and check their email, check the Internet, and then we'd drop off (lose the connection)," said Rarick, referring to the effects caused by the short surge in online traffic at the hotel. "We would have to reestablish our Internet link, and we'd be fine most of the day."

Maintaining connectivity proved to be a challenge. Although BAT had a backup—using the BCC team at MSFC—the international partners didn't. Computers in Houston were essential to providing command and control from



Picture of Hurricane Ike taken by the crew of the International Space Station flying 220 statute miles above Earth.Credit: NASA

the international partners to ISS. This was a major reason to keep Houston up and running for as long as possible. McMillan made constant calls to the hurricane Rideout team about the status of various computers and servers. Some had to be covered with plastic wrap; others had to be shut down entirely because of water leaks in the roof. Whenever Rideout delivered updates about equipment that had to be taken offline, McMillan recalled, "We'd think, "No, no! Not that one."

Progress on a Schedule

As Ike approached Houston, BAT had gone west, BCC team had gone east, and a Russian Progress vehicle had launched. Progress began its journey to the station on September 10. Ike's timing was less than ideal.

Docking a Progress spacecraft to the ISS is a critical operation that involves conducting thermal analysis and reorienting the solar arrays, among other things. The ISS flies at an inclination of 51.6 degrees, which is a tough environment in terms of thermal conditions. Certain changes in temperature can cause structures like the solar array longerons (long, sturdy rods that support the arrays) and equipment positioned outside the ISS to expand or contract. "We go through larger hot and cold periods than we originally planned for some space station hardware," explained Rarick. "So when we have to configure for a docking, we have to do thermal analysis." This thermal analysis has to be done on a specific Houston computer.

To obtain the details needed, the thermal analysis team had to get creative. In order to communicate, the team had to relocate to an out-of-the-way coffee shop to get a Wi-Fi connection. "We had to send them the information needed to run the analysis back in a deserted office," said Rarick. "They would get the computer up and running, do all the analysis, and tell us if the plan was thermally acceptable."

Additionally, a Progress vehicle approaches the ISS in such a way that its thrusters can damage the solar arrays if left unmoved. Reorienting the solar arrays usually decreases the amount of energy they can acquire, which means instituting energy management procedures. Mission control powers down certain modules to conserve energy prior to an event. It is a complex maneuver, explained Rarick. "One loss of one computer and we can't put our solar arrays in the right position."

"For these events we always have full redundancy." But the BAT did not have the necessary redundancy in its systems. BCC didn't either, but it had some redundancies that BAT didn't. BAT handed over control to McMillan. "Realistically, we were going to get into the situation eventually," said McMillan about the Progress docking. "The fact that we got into this situation right out of the gate took a lot of us by surprise."

Space Station Aside

While station operations, computer servers, and buildings comprise one part of the emergency response plan, taking care of families, relatives, employees, children, and pets is the other. "Getting your house ready is no easy task," said Rarick. "Literally, you go through your house and say, 'What do I care about?'"

Evacuation isn't easy. Aside from two minor freeways, I-45 is the one and only major freeway leading out of Houston. "Pick the wrong way, and you're still in the hurricane," said Rarick. "People get hurt, pets get lost, homes are destroyed, valuables are lost."

Most of all, Rarick and McMillan appreciated having information. "All of us were just glued watching the news, trying to figure out what was going on," recalled McMillan. "After Ike's landfall, I was incredibly impressed by how the management team, not just the management, but the team as a whole back in Houston pulled together to get information and help each other out."

Volunteer crews deployed around the community to clear driveways, cut down tree debris, share generators, or visit homes to send status reports back to families who couldn't return yet. Some areas didn't get power back for weeks. Stagnant water provided a breeding ground for mosquitoes. Dead animals had to be removed. Homes had to be salvaged, and communities rebuilt.

"There was a huge effort, and it was very well organized. NASA management teams put volunteers on teams, called you, and told you where to show up and what to do," said Rarick. "It was significant. Those of us who were unable to return home were well taken care of."

Ready for the Next Time Around

Despite the havoc Ike wreaked, JSC received praised for its response. "The JSC team did an outstanding job of preparing prior to the storm and recovery afterwards – through these difficult experiences our collective knowledge was expanded," wrote Mike Coats, center director of JSC, in a **lessons learned report** on Ike. "Most of the stuff that became lessons learned were holes that we didn't anticipate or didn't fully understand," said Rarick. "Not because of a lack of preparation."

Preparations like pre-storm covering of electronic equipment and mitigation after Ike's passage were vital in prevention of major damage at Johnson Space Center. Here workers are in the center's Mission Evaluation Room after the storm. Credit: NASA

One of the biggest lessons Ike brought to light was orchestrating center preparedness. Starting with Level 5 (the beginning of hurricane season in May) and ending with Level 1 (the hurricane has arrived), JSC choreographed all the preparation of all the center's assets. However, while preparedness levels have predetermined schedules to them, hurricanes don't.

Mission Control has a large stack of evacuation checklists. "Everyone pulls out the procedure, we walk through them, and we track when they are done." They are systematic and vigilant with these checklists, Rarick explained. A problem arises when the predetermined level says it takes 24 to 38 hours to complete, but the storm changed pace and instead there are only four hours. Said Rarick, "You have an expectation and you go into work one day and you think 'OK, we're on Level 4. How do we get to a Level 3 late today or tomorrow?' Suddenly, it's late afternoon and JSC is at Level 3, but MCC isn't."

"We spent a lot of time starting in early 2008 to really go through those procedures with the new (BCC) capabilities in mind to try and figure out what was the best way to choreograph all of that," added McMillan. "We had done that previously when we just had BAT," said McMillan. Even then there were things they didn't foresee. "After Ike, we went back and made some changes to the procedures because of things that we had learned," said McMillan.

Other lessons ranged from IT and connectivity issues to maintaining employee contact information and making sure there was enough staffing. "When Ike came around, the good news was we had done this in terms of actually putting people in place," said McMillan. A team was dispatched for one night during Gustav, which diverted to Louisiana instead. The bad news, she continued, was that the "one-night Gustav" mentality was still present when Ike hit—the BCC team was dispatched for over a week, supporting operations around the clock, and shift backup couldn't come fast enough.

While procedures for center shutdown are practiced annually, aftermath recovery was not as well developed. Tracking down the right personnel to access specific systems for contracts, funding, and procurement needed for center recovery and rehabilitation was a challenge. "It's difficult to plan for the multitude of outcomes," said Rarick.

Being adaptable and maintaining a global view of the situation was difficult but essential to everyone involved. "The exchanges that we had with the center ops folks were really interesting," said McMillan. "They really had to think about what type of information they needed to convey to center ops in order for it to mean something in terms of evacuation readiness. Those of us in space station aren't used to having to think about things like the team that's working on the roof of whichever building. Meanwhile, the center ops folks are not used to worrying about whether or not the right server is up to support a Progress docking. There were a lot of conversations where we ended up looking across the table at each other saying, 'Huh?'"

"Even though we had set up a plan and prepared for everything, it was the ability to make changes at the last minute, or accommodate whatever narrow situation you were in to find a way through it that made it successful," said Rarick.

Extraordinary Lessons

June 14, 2011 — Vol. 4, Issue 4

Shot down, tied up, and imprisoned somewhere in China, two CIA operatives were told by their captors, "Your future is very dark."

On a clear winter night, November 29, 1952, Central Intelligence Agency (CIA) operatives Richard Fecteau, 25, and John Downey, 22, boarded a plane to retrieve an informant in Chinese territory. During a second pass over the pick-up site, heavy fire from the ground brought the plane down. Their informant had been "flipped"—he had shared information with the Chinese about their mission. Shocked and confused, Fecteau and Downey, the only survivors, were immediately taken away for

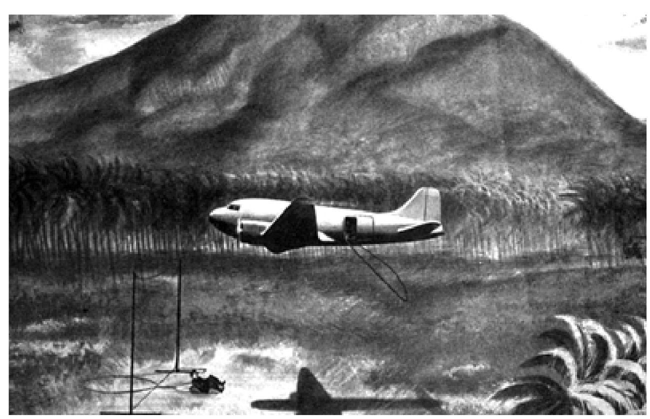


Illustration of the snatch pickup, from 1944 U.S. Army Air Forces manual Image Credit: Central Intelligence Agency interrogation and imprisonment. It would be twenty years before either man would return home.

A half-century passed before the Downey-Fecteau story could be told in full. Before institutional memory could fade, the CIA captured lessons from this incredible story: the communication shortfalls that preceded the ambush; the extraordinary psychological stamina that sustained both agents; and the creative, dedicated maneuverings of the agency to provide for the men and their families during their absence and ultimately bring them home.

At CIA Headquarters, a painting of the Downey-Fecteau nighttime ambush hangs on a wall shared by images of other intelligence heroes like Virginia Hall, a World War II spy who received the Distinguished Service Cross, and Drew Dix, who singlehandedly assembled a small team and liberated the city of Chau Phu from Vietcong forces in 1968. Employees regularly stop and gaze. Not too far away stands the Memorial Wall, its 102 stars chiseled into the marble, commemorating lives lost in the line of duty. Among them is a star for Downey and Fecteau's pilot from that November night. More than fifty years since their story began, it finally can be told—and taught.

Tale of Two Agencies

The CIA, like NASA, is an organization defined by extraordinary individuals with extraordinary stories. And intelligence, like aerospace, is a tough business. Complexity and expectations rise without commensurate increases in resources. Successes usually go unheralded, while failure is subject to heavy scrutiny. And, to a certain extent, this is rightly so. Lives are on the line.

Congress created the Central Intelligence Agency with the passage of the National Security Act of 1947. Eleven years later, the Space Act led to the establishment of NASA. Both agencies grew up in the context of the Cold War competition with the Soviet Union and the perceived threat of global communism.

Downey and Fecteau with captured B-29 crew in a Chinese propaganda photo. (Fecteau is standing to the right of the table, reaching down for a meal. Downey stands in the center of the photo, up against the wall.) Photo Credit: Central Intelligence Agency

Both have also had their share of public failures over the last half-century. This year marks the tenth anniversary of 9/11 and the twenty-fifth anniversary of the *Challenger* accident—watershed events for these agencies and the nation.

Within the last decade, the intelligence and aerospace communities have had to respond and adapt to a dynamic world where information flows freely, technology is a blessing and a curse, smart networks define success, and transparency rules. While instinct may tell organizations to restrict and regulate information, taking this reality as a challenge to adapt and use the elements of the new environment to its advantage might be more effective.

Today, both agencies also face the challenges of resolving a "grey-green" generation gap. When NASA went to the moon, the average age in mission control was 26, whereas today it's closer to 50. At CIA, over half of the workforce entered the agency after 9/11. Passing on institutional knowledge is essential.

Center for the Studies in Intelligence

Knowledge sharing is particularly challenging in an agency of silos fortified by untold layers of security and secrecy. The Lessons Learned Program at the CIA is an initiative that started in 1974 with the establishment of the Center for the Study of Intelligence (CSI). Getting to its current form today took time. In an elite, unforgiving profession, admitting, much less embracing, the possibility of failure is not easy.

"A program explicitly designed to improve human performance implies that human performance needs improving," wrote Dr. Rob Johnston, director of the CIA's Lessons Learned Program, in his work Analytic Culture in the U.S. Intelligence Community: An Ethnographic Study. By gaining the support of agency leadership, Johnston was able to establish a resourceful knowledge sharing outfit. The CIA Lessons Learned Program produces case studies, oral histories, training, knowledge sharing events, and manages internal communities of practice. In a "failure-is-not-an-option" environment, having respected leaders share stories about past failures and successes stimulates learning and growth.

"It is important…that there be a voice in favor of openness to counterbalance the many voices whose sole or primary responsibility is the advocacy and maintenance of secrecy," Johnson wrote in Analytic Culture. This balance between restriction and freedom would optimize personal efficacy. In an increasingly transparent world, where organizations are sometimes forced to learn in public, one could argue that this type of organizational evolution is necessary.

To Be Better and Do Better

Supporting organizational knowledge sharing is a way to address big questions in pursuit of mission success. How did we get those guys home? How did we respond when all hell broke loose? What did we do when we got it really right?

Christa McAuliffe received a preview of microgravity during a special flight aboard NASA's KC-135 "zero gravity" aircraft. She represented the Teacher in Space Project aboard the STS-51L/Challenger mission. Photo Credit: NASA

Initiatives like the CIA Lessons Learned Program preserve valuable experience and knowledge within the institution before it walks out the door.

The *Challenger* and 9/11 tragedies are reminders of the necessity for organizational learning and knowledge sharing. So are the stories of Downey and Fecteau; Jim Lovell, Jack Sweigert and Fred Haise; Gus Grissom, Ed White, and Roger Chaffee; and countless others who made extraordinary sacrifices. Their stories provide fundamental lessons for current and future generations of practitioners.

U.S. Space Policy through the Looking Glass

June 14, 2011 — Vol. 4, Issue 4

Space policy remains a moving target in the post-Cold War era, according to space policy representatives from six presidential administrations spanning 35 years.

Officials from the Carter to Obama administrations gathered for "Evolution of U.S. National Space Policy," the latest George C. Marshall Institute event co-hosted by the Space Enterprise Council and Tech America on May 20, 2011.

Throughout the history of spaceflight, space policy has been driven by core themes, including U.S. leadership in space, environmental monitoring, private sector integration, national security, and technology development. Shaped by both economic conditions and international relations, these themes have built upon one another and evolved over the course of each presidential administration.

In its first 30 years, space policy was inseparable from the politics of the Cold War. When the standoff with the Soviet Union ended, space policy faced an identity crisis. "That sense of animation, that sense of motivation was removed. We had a series of concerns right away with the end of the Cold War," said Mark Albrecht, former executive secretary of the National Space Council during the first Bush administration. "This is where it gets interesting."

The question facing policymakers was what space policy should look like in the post-Cold War era. Precision guided munitions during Desert Storm in 1991 made the case for sustainable military space applications. At the same time, NASA was in a state of dramatic transition. It was still recovering from the *Challenger* accident. The space station had increased in cost by 400 percent. Early discussions about global climate change led to plans for large Earth-observing satellites, which were later deemed unsustainable and restructured into smaller missions. The "Faster, better, cheaper" methodology began to reshape the agency's approach to spacecraft development.

The panelists addressed questions about how the issue of increased costs and decreased capabilities relates to space policy. Government institutions have become old and increasingly bureaucratic, some panelists said. A burdensome procurement process drives up cost, and any long-standing reliance on one type of space transportation (e.g., the shuttle) isn't sustainable. Panelists agreed that the system needs to find ways to become quick and nimble again in order to address these issues.

A close-up camera view shows Space Shuttle Columbia as it lifts off from Launch Pad 39A on mission STS-107. Photo Credit: NASA

An artist's concept of the experimental X-33 plane during flight. The program was cancelled in 2001. Image Credit: NASA/MSFC

Richard DalBello, former assistant director for Aeronautics and Space in the Office of Science and Technology Policy (OSTP) during the Clinton administration, reflected that this sentiment prevailed at the time. "I think the sense was that space was not as exciting as all of this. Space was slow, too bureaucratic, too expensive, and that there was some second and third guessing about the ultimate value of the investment," he said, noting that the era was characterized by the rise of the Internet and rapid technology development.

DalBello also discussed technology outcomes during Clinton's administration, such as the positive benefits of making GPS accessible to everyone and air traffic modernization. At the same time, DalBello and other panelists agreed that this was the beginning of a realization that there were unavoidable technology gaps holding exploration back. With the loss of the X-33 program in particular, DalBello said, "I learned a very important lesson: policy never trumps physics. You can say whatever you want, but if you can't do it, it won't happen. We just didn't have the technology."

This challenge of technology development persists to this day. There is a need for more "makers, doers, and dreamers," said Jim Kohlenberger, who served at OSTP during the Obama and Clinton administrations.

Based on his previous experience in the second Bush White House, Peter Marquez, former director for space policy in the Obama administration, observed that, "We can trace failures in policy back to not the words that were written, but the failure to implement the policy." Timing is everything. When it came time to roll out President Obama's National Space Policy, he drew on lessons learned from the Bush administration and made sure to get it out quickly.

Bretton Alexander, former advisor on space issues at OSTP during the George W. Bush administration, said that the *Columbia* accident was a watershed event for the policy community's understanding of human spaceflight capability. "With it came a recognition of the civil human spaceflight program as being fundamentally different than what we had thought," he said, noting that the shuttle was not the operational system that many had assumed it to be.

Alexander also viewed the accident through the lens of long-term policy failure. "Within the organization there wasn't a sense of why we were doing it, where we were going, the importance of it. That had been lost," he said, citing the *Columbia* Accident Investigation Board Report's assertion that there was a lack of a national mandate for the human spaceflight program. "It was a failure of national leadership over thirty years."

The panel concluded with a discussion of the future of human spaceflight, where perspectives ranged from lamentation to optimism. "[There were] two incredible government accomplishments in 1969: we landed on the moon and we invented the Internet. But they took two fundamentally different paths," said Kohlenberger, noting that the Internet moved into the commercial sector in the 1990s. "The difference is that we've kept space as an entirely governmental program." He and other panelists discussed the promise of synergies between government and commercial space projects.

Working Outside the Box at Johnson Space Center

July 20, 2011 — Vol. 4, Issue 5

What impact does a room really have on your work?

Ask someone where to find "the sp.ace" at Johnson Space Center (JSC) and they might look at you as though you've queried the location of Platform 9 ¾ or a wardrobe leading to Narnia. Between Buildings 34 and 585 at JSC sits Building 29. It once housed the Apollo astronaut centrifuge, and later the Weightless Environment Training Facility (WETF)—a precursor to the Neutral Buoyancy Laboratory—which trained astronauts for Hubble repair missions. Today Building 29 supports another mission: collaboration.

Inside one of the high bays overlooking the former home of the WETF is a work area available to everyone at the center. The decor is simple and functional: whiteboard tables, colorful rolling chairs, mobile desks and whiteboard walls.

The sp.ace in Building 29 at Johnson Space Center. Photo Credit: NASA JSC/ Christopher Gerty

Have an idea? Write it on the table or a wall. Share it on a screen. Need a bit of privacy? Go to the neighboring room ("the fishbowl") and work there.

Open, light, and flat, the sp.ace is an environment where people and ideas can connect, collide, and coalesce. It is a place where the traditional workforce meets the increasingly transient one. As project teams become more geographically dispersed and the demand for cross-disciplinary innovation continues to grow, some organizations are creating work environments that foster disruptive ideas and unexpected solutions.

Beyond Cubism

Collaborative spaces are not new. Early coffeehouses from the 1600's were hotbeds of social interaction and collaboration. Walk into any on-campus college café and you'll see writing on the walls and hear lively conversation. While the fundamentals of human collaboration have not changed since the Enlightenment, the amount of information and knowledge available through technological advances has. The challenge facing organizations is to standardize the technology used to collaborate and connect, not the location of the worker.

Until the mid-1960s, typical office spaces consisted of open areas lined with orderly rows of desks. Paperwork was filed in cabinets or neatly piled in stacks on desktops. As the amount of information passing through organizations increased, something had to give.

In 1968, Robert Propst invented the cubicle, which drastically altered the office work environment. While the original intention of the cubicle was to liberate workers from piles of paperwork and give them the opportunity to spread out, visualize information differently, and establish a sense of identity at the office, Propst's invention took another path. Now a symbol of compartmentalization, the workplace is undergoing a shift away from "cube farms" toward more collaborative working spaces.

Organizations like SpaceX have open, flat work environments designed to reflect their flat organizational structure. **Fuji Xerox** has rooms in Europe and Japan that are designed to elicit certain types of thinking – a sort of "cognitive ergonomics," a term used by researchers at large office furniture companies like Steelcase and Herman Miller. Companies from Google to Capital One have made open, transparent, collaborative work spaces available to their employees.

Work real estate is at a premium. Projects are increasingly interagency and international. Employees don't always utilize an office—they're getting the job done elsewhere. IBM, for example, has done away with office space for tens of thousands of its employees. Practices such as "hotelling," where employees are given unassigned spaces in a work environment, are being used to meet the needs of nomadic workers. This way of working is making its way to government.

Collaborative work taking place in the sp.ace at Building 29 at Johnson Space Center. Photo Credit: NASA JSC/ Christopher Gerty

In December 2010, President Obama signed the Telework Enhancement Act "to improve teleworking in executive agencies by developing a telework program that allows employees to telework at least 20 percent of the hours worked in every two administrative work weeks, and for other purposes." This June, executive agencies passed the first milestone of informing employees who meet the teleworking criteria that they are eligible for a new way to work. The next steps include acquiring technologies to allow for incorporation of telework into agency operations and policies in order to decrease real-estate costs. Collaborative workspaces allow organizations to optimize the use of their work real estate, and workspace is no longer defined by one function or set of walls. It becomes adaptable, flexible; anything the organization wants it or needs it to be.

The Sp.ace, the Sandbox, and Fab Labs

NASA is accustomed to collaboration on many levels. Collaborative spaces exist at Ames Research Center and the Jet Propulsion Laboratory, connected by hyperwalls—large multi-screen displays—to collaborate on projects such as high-resolution image analysis from Mars. The pixel resolution allows for scientists separated by nearly 400 miles to collaborate and plan out a rover's path. The JSC sp.ace

The "Sandbox" at Johnson Space Center. Photo Credit: NASA JSC/ Christopher Gerty is a modest beginning to something that hopes to grow. It's a place for people to congregate and spur imagination, creativity, and curiosity. But it's only a start.

Plans for another collaborative working space at JSC are afoot. The "Sandbox" will draw on the global success of the MIT Fabrication Laboratories ("Fab Labs") which started gaining recognition in 2002. Fab Labs were founded on the premise of giving people tools to create things rather than consume them. The Sandbox, used to be warehouse that held old boxes of this and that and then acquired a variety of electronics, welding, and machining equipment in addition to an open meeting area. It is the hardware/prototyping equivalent of the sp.ace in Building 29 and will be virtually connected to other collaborative working spaces. As this new space evolves, a sort of collaborative space "cookbook" with information about standardizing connections (e.g., HDMI inputs), bandwidth requirements, audio and video connections and positioning, and power needs (e.g., easily accessible power strips) will be made available for others to create other collaborative spaces capable of connecting with established ones.

While the creation of collaborative spaces at JSC is continuing to evolve, the JSC "sp.ace" has already had success with a designated coworking week. Anyone from flight controllers, to administrative assistants, to project teams utilized the space to meet their needs or simply check it out. Throughout the week, as new faces trickled in and familiar ones returned for another visit, it was apparent that an entirely different wave of information and knowledge sharing driven by increased technological capability is upon us. Traditional offices aren't supporting workforces like they have in the past, and organizations are starting to adapt.

Aaron Cohen on Project Management

July 20, 2011 — Vol. 4, Issue 5

A pioneer of human spaceflight projects offered five rules for avoiding project management pitfalls.

[Editor's note: As the space shuttle moves from the launch pad into the history books, it seems appropriate to revisit the wisdom of Aaron Cohen about successful project management. Cohen joined NASA in 1962 and served in key leadership roles critical to the success of the flights and lunar landings of the Apollo Program. From 1969 to 1972, Cohen was the manager for the Apollo Command and Service Modules. He oversaw the design, development, production, and test flights of the space shuttles as manager of NASA's Space Shuttle Orbiter Project Office from 1972 to 1982. After serving as Director of Engineering at Johnson for several years, he was named director of the center in 1986, serving in that post until 1993.

The text below is an excerpt from "Project Management: JSC's Heritage and Challenge," which was originally published in 1988 in the anthology "Issues in NASA Program and Project Management" (NASA SP-6101).]

Whatever priorities are dictated by the environment, a project manager can never equally satisfy all elements of project management. There is no exact project management formula or equation for making performance-cost-schedule trades. But the lessons I have learned from people like Robert Gilruth, Max Faget, Chris Kraft and George Low—and from my own experience—tell me that there are several important principles in maximizing the probability of success. Those factors sometimes contradict one another and they must be applied on a case-by-case basis, but they are nonetheless valuable.

First, you must fearlessly base your decisions on the best information available. As a project manager you will have many different considerations with regard to each programmatic issue. Simply by making a decision, you ensure that you probably will be right more than half the time.

Many times during the life of a project, a project manager will be faced with decisions that need to be made in a timely fashion, and either all the data is not available or it will not become available in time. In other words, the time and effort spent in trying to obtain additional information may not be worthwhile. A specific example of this occurred during the early design phase of the Orbiter. The avionics system was being formulated and a microwave scanning

Aaron Cohen served as NASA Acting Deputy Administrator from February 19, 1992 to November 1, 1992. Mr. Cohen started at NASA's Johnson Space Center in 1962 working on the Apollo program. After Apollo he served as Manager of the Space Shuttle orbiter, directing the development and testing of the orbiter. In 1986 he assumed the position of Johnson Space Center Director. Photo Credit: NASA beam landing system (MSBLS) was being considered as a navigation aid. At the time, the MSBLS was pushing the state-of-the-art. The question before me: Should I use current, proven technology or should I try to push the state of the art and wait for such an advancement in the technology? I based my decision to push for the new technology on the data I had and the desire of my team to use the system. We made a decision, and it proved to be correct.

Second, you must make decisions in a timely manner. If you are decisive early and are wrong, you can still correct your error. During the Orbiter design, development, test and evaluation phase, I was forced to make many trades in terms of performance, cost and schedule. On one particular occasion, I was reviewing thermal system structural test requirements that contained a number of articles such as parts of wings, parts of the mid and forward fuselage and their thermal protection systems. The technical team needed to test all of the articles, but they were too large to test all at once, and I had a limited budget. After spending a full Saturday in review of all the test articles, I eliminated several despite the extreme concern of several of the technical experts I had supporting me. Weeks later they came back and argued their point of concern again. This time, their point struck home and I reversed myself and put the test articles back into the program. By making a timely decision, I had given myself a chance to correct a potential error.

Third, if you can fix a problem by making a decision, do it. During the checkout of Apollo 11, the Inertial Measurement Unit (IMU) of the lunar module was slightly out of specifications in gyro drift. The analysis showed that you could accept a little more degradation and still perform the mission. The questions before management: Do we understand the reason for the gyro drift, and could this lead to a greater degradation and threaten the success of the mission? Changing an IMU out of the lunar module on the pad was not an easy task, and we would be risking major damage to the fragile structure of the lunar module if one of the heavy instruments were dropped during a pad change-out. A group of us discussed this problem with George Low, then Apollo program manager. We strongly recommended to him that we should not change out the IMU. His comment was: "If you can fix a problem by making a timely decision, do it." We replaced the IMU.

Fourth, always remember that better is the enemy of the good. You can never solve all of the problems. If you have obtained an acceptable level of system performance, any "improvements" run the risk of becoming detriments. Right now, we are struggling with this very situation [in the Shuttle program] as we try to improve the design of the solid rocket motors and add emergency egress systems to the Orbiter. Each improvement brings with it a price in terms of weight. Each additional pound reduces the margin we have in the amount of thrust available to reach orbit. We have had to ask ourselves, "At what point do these new safety features become liabilities?"

Fifth, don't forget how important good business and contract management are to the successful operation of

Major General J.A. Abrahamson, right, talks to JSC Director Christopher C. Kraft, Jr., (seated left) and Space Shuttle Program Manager Glynn S. Lunney on the back row of consoles in the mission operations control room (MOCR) in the Johnson Space Center mission control center. Abrahamson, second right, talks to JSC's Aaron Cohen, right, as Kraft (seated left) and Lunney listen in mission control. Photo Credit: NASA

a contract. Project managers must realize that when they manage a contract they should do their best to be fair to both the government and the contractor. In order to do this, they need strong project controls on budget, schedule and configuration. The project manager must be sure the changes that are made are negotiated promptly and equitably for the government and contractor. Fairness in dealing with the contractor is the most productive way to do business. You want to penalize when appropriate, but you also want to reward when appropriate. To establish what is appropriate, you must set the ground rules early. The first signs of project management failure are budget overruns and schedule slips. This can be understood and potentially avoided or minimized by good project control and contract management.

Last, and most important, you must be people-oriented. It is through people that projects get done. Dealing with people is extremely difficult for many project managers who have an engineering background and more comfortable working with an algorithm than explaining how to use one. Good project managers surround themselves with talented people who will speak up when they believe they are right. They make themselves available to their bosses and to the people who support them. They listen when people express their concerns, and make people want to express their concerns by explaining decisions that contradict the advice given. They accept criticism without being defensive and are able to reverse their decisions when they are wrong.

One of the most vivid and memorable experiences I've had in this regard happened during the preparation for Apollo 8 in early December 1968. The preparations had been going very smoothly without any big issues needing to be worked for several weeks. Then it happened. About two weeks before the flight I was told by the contractor, North American Aviation, and JSC propulsion subsystem managers that we had a potentially serious problem with the service propulsion system (SPS). We had just finished some tests in the configuration that we were going to use for lunar orbit insertion.

Apollo 8 was going to place the CSM on a free-return trajectory, which meant that if we did not perform an SPS burn behind the Moon the spacecraft would automatically return to Earth. The SPS fuel injector was fed by a pair of redundant systems. We wanted both of them to be active during the lunar orbit insertion burn so that if one feeder line malfunctioned, the other would get propellant to the SPS. The tests we had just finished were in this configuration, but it was the first time they had been used and both lines had been dry before the test. The tests showed that if we started the burn with both lines dry, a pressure spike occurred that could cause a catastrophic failure in the SPS. If both lines were wetted, however, the pressure spike would not occur.

I got very upset when I was told this, but the test engineers stood their ground. They told me very firmly that the problem had to be addressed, and they presented a good solution. By firing the SPS on a single system out-of-plane burn during coast—which would not disturb the translunar free-return trajectory—we would have both systems wetted by the time we needed to use them together and, hence, avert the high-pressure spike.

Now it was my job to call my boss and let him know what I knew and how to fix the problem. I had no qualms about doing this because my boss, George Low, had taught me several important things by his actions and words: get out and touch the real hardware; when things go wrong, look for innovations, the unusual solutions, or try to meet your commitments no matter what; and have great respect for your fellow human beings.

Shuttle Trackers

September 28, 2011 — Vol. 4, Issue 7

A team of thirty-five trackers worked together to provide the photographic story of a space shuttle launch.

When a piece of foam the size of a briefcase hit the leading edge of *Columbia*'s left wing 81.7 seconds into the launch of STS-107 on January 16, 2003, no one saw. It wasn't until the following day that images from cameras on the ground revealed the strike and triggered a series of conversations

Cameras inside of explosion-proof enclosures near Launch Pad 39-A. Photo Credit: NASA APPEL

Camera inside of an explosion-proof enclosure pointed towards Endeavour one week before it launched on STS-134. Photo Credit: NASA APPEL

about what to do. The story of *Columbia* is just one example of the impact that imagery can have. Getting the right image is a story in itself.

Approximately 400 ground-based cameras recorded every shuttle launch after *Columbia*, an increase from previous missions that was recommended by the *Columbia* Accident Investigation Board Report. The report identified other upgrades to Kennedy Space Center's ground camera ascent imagery assets such as obtaining higher quality optics and higher image resolution. For each shuttle launch these assets were precisely calibrated to capture the data needed to make decisions about the progression of the mission.

Most stories about shuttle launch photography focus on the cameras and the massive tracking equipment. As with all NASA projects, though, it is the people behind the cameras and machines who make the visual story of a launch come to life.

A Mad Scientist Machine Shop

"Want to hear 400 frames per second?" asked Adam Nehr, instrumentation specialist. He flipped a switch and the camera chugged its way through a full magazine of film in less than a minute. The camera resembled many others sitting in a storage room across the hall. Inside there are rows of racks containing cameras, film, and tripods and at least one cabinet dedicated to the famous Hasselblad cameras used to capture lunar imagery during the Apollo Program. "This is what we have in terms of the smaller equipment," said Mark Olszewski, photo and media services manager. "These are the little toys."

The Photo and Media Services Center is home to a team of 35 men and women dedicated to seeing the shuttle launch story unfold amid the chaos of fire, gas, and debris during launch. Some took a winding path through various technical school curricula, while others transitioned to NASA from jobs ranging from shooting high-speed commercial imagery for locomotive companies to photographing autopsies.

"All of us here are construction technicians, welders, [or] machinists who are able to fabricate all kinds of stuff," said

Nehr. "We can make anything in metal, wood, plastic." The team can design, build, and repair optical equipment as well as maintain and calibrate high-speed motion picture equipment. The team prepped the cameras (the film was installed by feel in total darkness) and placed them in explosion-proof boxes around the pad." Generally accustomed to flying below the radar and getting the job done right, "we become pretty important 11 milliseconds after something goes wrong," said Nehr.

The Lesser Known PADD

Each camera for a launch has a specific job to do. For shuttle, there were hydrogen burnout cameras on the launch pad to capture the diamond shockwave that comes out of the engines. There were cameras inside the Tail Service Mast (TSM) recorded the human-sized carrier plates as they were pulled back and shut into the TSM enclosure. There were cameras set up to capture the gimballing and ignition of the engines, the release of the explosive bolts holding the shuttle up, and to record the movement of the twang. "There's a camera for every mechanical function that we need to quantify," said Nehr.

Each camera is prepared according to the type of image it will capture. "We need to set up our equipment to acquire that image precisely," said Nehr. Specific calculations for each camera are documented in the Photographic Acquisition Disposition Document (PADD). Derived from the Program Requirements Document for the shuttle, the PADD defines the imagery requirements according to what the imagery analysis team needs to do its job after a vehicle launches.

"The PADD specifies what the intent of the image is," explained Nehr. Shutter angle, shutter speed, and frame rate, are calculated for every single camera, in addition to the shuttle's path and gas velocities so that the photographers know how fast something might be moving through a frame. "They have to be calculated so that any credible event that we would see is kept sharp," explained Olszewski. A blur streaking through an image can render it useless.

There were cameras calibrated for short-, mid-, and long-range imagery. Some sat on the pad, next to the pad, around the perimeter of the pad, or even many miles away. Perhaps the best-known cameras sat on a tracking device called a Kineto Tracking Mount (KTM). It looks like something straight out of a Star Wars film. One side of the KTM carried a film camera packing 1,000 feet of film, and the other housed a HD-quality video camera. A manned tracker used a spherical joystick to follow the shuttle skyward. Unmanned KTMs were remotely controlled and sat as close as two miles from the pad.

For every shuttle launch, a total of 14 KTMs were deployed to stations from Cocoa Beach to Daytona. "We set them up here in the hanger, put all of the cameras and lenses on them, make sure they're balanced and everything works just right, and then we tow them out to the field," Ken Allen, chief electronic technician, who has been with the team for over 23 years.

Operator Kenny Allen works on the recently acquired Contraves-Goerz Kineto Tracking Mount (KTM). Trailer-mounted with a center console/ seat and electric drive tracking mount, the KTM includes a two-camera, camera control unit that will be used during launches. Photo Credit: NASA

Allen started his career with NASA working telemetry for STS-1 on an island in the Caribbean. He later transferred to KSC during the days of the KTM predecessor, a tracking mount called the Intermediate Focal Length Optical Tracker (IFLOT), which used World War II anti-aircraft gun mounts retrofitted with cameras instead of artillery. They have been used to capture imagery for launches from the late 1950s to shuttle. Not quite fast enough to track the faster rockets of today, NASA started using KTMs, which were more capable, in conjunction with the IFLOTs in the late 1980s.

"I actually took these (the KTMs) off the truck when they showed up," said Allen. The KTMs were computer controlled and modern and Allen took to them immediately. "The old-timers that were here back then didn't want anything to do with them," he laughed. "That's how I ended up in this section. I knew the electronics and could take care of them."

Not Your Average Photostream

Just before rollback of the Rotating Servicing Structure, Nehr would carry a heavy bag of equipment up to the shuttle stack. He meticulously photographed the tiles and the forward reaction control system, documenting everything he saw. Of the 2,000 plus images he took, bird droppings were a common item he took care to note. "To the laser range finder on the end of the robotic arm they used for tile inspection [in space], bird droppings look exactly like tile damage," Nehr explained. Tile damage can be cause for a spacewalk, an unwanted risk and waste of valuable time if the tiles aren't really compromised. "I've had thousands of published pictures," said Nehr, "but I tell people some of the most important pictures I've ever taken are of bird poo."

Another set of photographs he was responsible for were of tiny pieces of tape placed where the external tank connected to the belly of the shuttle. Once the tank was jettisoned, the doors closed in a specific way. "We position the tape so that it shows just a little bit [when this happens]," he explained. "When we examine the photographs, if there's more tape

Operators Rick Wetherington (left) and Kenny Allen work on two of the Contraves-Goerz Kineto Tracking Mounts (KTM). There are 10 KTMs certified for use on the Eastern Range. The KTM, which is trailer-mounted with a center console/seat and electric drive tracking mount, includes a two-camera, camera control unit that will be used during launches. The KTM is designed for remotely controlled operations and offers a combination of film, shuttered and high-speed digital video, and FLIR cameras configured with 20-inch to 150-inch focal length lenses. The KTMs are generally placed in the field and checked out the day before a launch and manned 3 hours prior to liftoff. Photo Credit: NASA

showing than there should be, we know the doors didn't shut properly."

After a launch, the team put together what is called a 'quick review' or 'quick video' within an hour or two after liftoff. This is the HD video of the launch that is sent to the image analysis team called the Intercenter Photo Working Group. "While that's happening we're gathering film from each of the cameras and getting it together to have it processed." They had approximately twenty-four hours to deliver.

A Thousand Words

Being able to answer the simple question "Did you see that?" is important to mission success. From the camera boxes that were embedded into the Apollo launch ring stands to the place where periscopes used to peer out of bunkers to watch Mercury spacecraft launch ("That's how they watched it back then in the days before easily usable video cameras," explained Nehr.), being able to actually see what's happening during liftoff is critical.

"A picture is worth a thousand words," said Olszewski. "It's that simple. Try to describe it verbally or try to write it down exactly as you've seen, it takes too much time. Sometimes you don't have the right words. Sometimes you know how to describe it. But if you take an image, you're looking at it. You don't have another person's perception of what they thought they saw."

When an anomaly or a failure occurs, often it happens so fast that the human eye misses it, perception distorts it, and memory fades. Said Nehr. "The only thing you've got left is imagery."

Something to Shout About: Bloodhound Supersonic Car

October 28, 2011 — Vol. 4, Issue 8

The Bloodhound Supersonic Car aims to set a new land speed record and a new standard for openness in projects.

Project Director Richard Noble and his team are building a car that will go zero to 1,050 miles per hour (mph) in 40 seconds. Named after Britain's 1950s Bloodhound Missile Project, the Bloodhound Supersonic Car (SSC) car is 12.8 meters long, weighs 6.4 tons, and cruises on high grade aluminum wheels, which will experience radial stresses of up to 50,000 times the force of gravity at full speed.

The project is risky, dangerous, and unprecedented. Focused on building the safest car possible, Noble's Bloodhound team intends to overthrow the current FIA World Land Speed Record by 30 percent. "It's such a huge leap, of course we're going to get into trouble," said Noble. "We're going to learn an awful lot as we develop it."

World records aside, the team wants to capture the attention of students and inspire a new generation of engineers.

The BLOODHOUND SSC Show Car outside Coutts Bank in The Strand, London. 17th October 2010. Project Director, Richard Noble OBE. Photo Credit: Sarah Haselwood

Genesis

In 1898, French driver Gaston de Chasseloup-Laubat set the world land speed record at 39 miles per hour (mph). Fast-forward to 1970, when after decades of battle between the Americans and British, an American-built car called Blue Flame set a new record of 630 mph. "We in Britain were very keen to get it back again," said Noble. "Or, at least, I was," he laughed.

Noble assembled a team to build a new car, Thrust2. With Noble literally in the driver's seat, Thrust2 set a new record of 634 mph in 1983, sparking a race for the sound barrier.

Building and modeling cars intended to travel upwards of 600 mph was difficult, dangerous, and nearly impossible. Noble had pushed the limits with Thrust2. "The [aerodynamic] data was varied and not reliable," said Noble. What designers needed was a transonic wind tunnel with a sort of car treadmill capable of speeds up to 900 mph, he explained. This didn't exist.

With competitors already at work, Noble decided to throw his hat into the Mach 1 race with Thrust SSC. This time around, Chief Aerodynamicist Ron Ayers insisted on modeling the car. Software programs in the early 1990s facilitated new ways of using computational fluid aerodynamics (CFD) to model Thrust SSC, but Ayers wanted to qualify their results. The team went to a long rocket test track, normally used for accelerating warheads up to Mach 3 and slamming them into slabs of concrete, and used a modified rocket sled to confirm their results. They ran 13 tests of their car and compared it to their CFD data. "Amazingly, we found there was just a 4 percent variation in the data," said Noble. This proved that the car was safe and viable.

The Bloodhound SSC Show Car at the Bloodhound Technical Centre. September 2010. Photo Credit: Flow Images

In 1997, Thrust SSC went supersonic five times in the Black Rock Desert of Nevada. Fifteen miles away in the town of Gerlach, the sonic boom knocked the covers off the classroom sprinkler system. "We all said that we would never, ever do this again," said Noble. Little did they know they weren't done—with building supersonic cars or rattling educational establishments.

Meeting with the Minister

After Thrust SSC's run, the late Steve Fossett, a world-renowned aviator and sailor, expressed an interest in overtaking the new speed record. If they waited, Noble and his team would spend five years studying how Fossett bested them, and then another six years building a defender. "We all looked at each other, got slightly grey-haired, and decided eleven years was too long," said Noble. "We'd better do it now."

The new car, the Bloodhound SSC, would shoot for 1,000 mph. Two jet engines on the car brought about too many design difficulties. A combination of one jet engine and one rocket motor was more feasible. Lightweight, small, and fuel-efficient, the Eurofighter-Typhoon EJ200 jet engine would be a perfect fit. However, there was only one place to get the engine: Britain's Ministry of Defence.

Driver Andy Green arranged a meeting with then-U.K. Science Minister Lord Paul Drayson, who formerly held a post in the Ministry of Defence. Drayson also happened to race cars. "The meeting remained very friendly until I asked him for the jet engine," Noble chuckled. Sensing they had failed dismally, they started to retreat from the room.

"Then Drayson said something that changed all of our lives," said Noble. "He said, 'Look, there's something you could do for us.' I said, 'Of course, Minister, what can we do for you?'" Drayson explained that the Ministry of Defense was having a problem with recruiting engineers. There didn't seem to be any in Britain anymore. During the 1960s, there had been a new airplane every year, which got kids excited and motivated them to become engineers. Drayson told Noble and Green that was the goal: they could have their engine if they agreed to start an education program with their project.

Noble agreed and shook Drayson's hand. "We walked out of his office intent on setting up an enormous education program, which we knew nothing about."

Engineering: A Dead Subject?

Noble's team went to work researching the state of education in Britain. "We found all sorts of terrible things

The Bloodhound SSC Team after the unveiling. (July 19th, 2010. Farnborough) Photo Credit: Nick Chapman

were happening," he said. Britain's skilled workforce was on the decline, its students were sliding in international rankings, and the country's information technology sector was dismal. They needed to create an Apollo-effect—to inspire people to change their lives because of this project.

With their posters and a model of the car, the Bloodhound team attended education exhibitions across the country, talking to as many STEM (science, technology, engineering, and mathematics) teachers as they could. Their conversations went something like this:

"What's it like teaching STEM?"

"Absolutely awful. It's an absolute nightmare. The kids aren't interested. They are very arrogant. All they think they need to know how to do is add, subtract, and work percentages."

"Sounds pretty bad."

"It's like teaching ancient Latin or Greek. You know, dead subjects."

Their conversations proved enlightening. "We needed to do something exciting," said Noble, "but above all, we had to be able to share the information." If they were going to educate Britain, teachers needed to be able to understand the charts, models, and drawings so they could make new lesson plans and explain it to their students. Every aspect of the project had to be entirely accessible.

This lack of secrecy initially worried the Bloodhound team. Then they realized that their fears were unnecessary. The only rules for the land speed record are that the car must have at least four wheels and be controlled by the driver. "All of the cars and all of the challengers are completely different," said Noble. "The technology simply won't transfer from one competitor to another. We realized that we could make all of the data available. Absolutely everything."

Nitrous: Not Quite So Funny

The Bloodhound team is blazing a new trail. They still have many challenges to overcome, but have learned a great deal so far. One particular lesson came from choosing the oxidizer for their hybrid rocket motor. The team thought it had an easy answer: nitrous oxide (N_2O). Safe, reliable, and easily accessible, N_2O seemed a sensible choice. Not so, warned one of Noble's peers—N_2O is not to be trifled with.

Noble investigated the claim. After scouring the Web, his team found a paper from 1936 that explained how pressurizing N_2O beyond 13 bar could cause an explosion. "Whole plants had been taken out by nitrous oxide explosions," explained Noble. Nitrous was also the culprit in a 2007 Scaled Composites explosion that killed three people. The Bloodhound team was shocked.

They selected high-test peroxide (HTP) as an alternative that is less likely to set off an N_2O -like explosion. Testing with smaller rockets has been successful, with the rocket motor running at 98 percent catalyst efficiency. The team is currently doing testing on the full-scale motor.

The Team: Grey to Green

Chief Rocket Engineer Daniel Jubb worked the N_2O problem. He joined the Bloodhound team in 2005 when he got a call from Noble for a meeting. Highly recommended by several seasoned rocket engineers, Noble drove out to Manchester to meet Jubb. "I discovered that I was face to face with a guy who was twenty-three," said Noble.

From Jubb to Ayers (who is in his eighties), Noble respects the importance of having a generationally diverse team. Typically, young engineers only see one part of a project. Rarely do they see the whole lifecycle. "Getting the overview perspective is very, very important," said Noble. The project is demanding, but offers young engineers (the youngest is 18) the opportunity for gaining tremendous experience and acts as a stepping stone to a future career.

Richard Noble and Andy Green with a model of Bloodhound SSC. Photo Credit: Bloodhound SSC

"It's very important from our point of view to use as many young people as we possibly can," said Noble. He finds the younger generation's rapport with technology enormously useful. "But, of course, they've got to be able to contribute to the project." The flat structure of the Bloodhound organization facilitates this. Everyone has their own set of responsibilities and the authorizations, and everyone in the organization is empowered. "Anyone can go fail the project if they wanted to," said Noble. "One would think this is some sort of undisciplined rabble, but it's certainly not."

"You end up with a very, very fast moving, highly motivated organization and therefore can do [great things] on very small sums of money," said Noble. (Thrust SSC was completed for £2.4 million, 12 percent of what their competitors budgeted.)

Something Incredibly Wonderful Will Happen

Partway through the project, Noble and his team realized there was a flaw in their openness plan. "If we were going to put up all of the operational data after each run on the web, we'd have to be very clever about the way we actually presented it," said Noble. "Unless people were given the appropriate education, they wouldn't understand the data. It would just be numbers to them and they wouldn't really be able to take part in the program."

Taking the lead from the highly successful Khan Academy, Noble partnered with Southampton University to develop educational tools the public will need to engage with the Bloodhound SSC data flow. Today there are 4,600 schools in Britain and 207 countries worldwide participating in the Bloodhound engineering adventure, as the team preps for their 2013 run in South Africa. Via the Bloodhound SSC website, anyone can be a part of the project through **games, videos, pictures, explanations of the car elements**, drawings, or **blog posts from Noble**. Just months ago, the team posted a suite of **40 computer-aided design (CAD) drawings** online to help people understand how the car was designed and built. There have been approximately 2,500 downloads of the drawings.

"It might well be that someone makes a [copy], which would be brilliant," chuckled Noble. "We could race!"

LAUNCH Energy: Leveraging Collective Genius

November 29, 2011 — Vol. 4, Issue 9

Ten energy innovations launched to change the world.

In the fifth floor conference room of Operations Support Building (OSB) II at Kennedy Space Center, Craig Jacobson switched on a small blowtorch. He held it to the end a strange-looking fire poker that consisted of a small, thin disc on one end and a power outlet on the other, with a light bulb attached. When the disc flashed white-orange, the bulb switched on. The disc, a 5-dollar-fuel cell invented by Jacobson in his garage, is an energy innovation he believes will empower people living off the grid and change the world.

Jacobson was one of 10 innovators selected to participate at the LAUNCH Energy Forum at Kennedy Space Center November 10-11, 2011. The event was a partnership that included NASA, USAID, Nike, and the State Department. The innovations ranged from cutting-edge technology to I-can't-believe-I-didn't-think-of-that solutions, and aimed to tackle some of the gnarliest energy problems in the world. "I don't just drink the Kool-aid," Jacobson said. "I made it."

Jacobson and the nine other innovators had 30 minutes to present their energy innovations to a council of thinkers, venture capitalists, architects, designers, biochemists, and engineers, and then to answer their initial questions. That was the easy part of their day. After a break, the real work started. The 30-plus council members divided into five tables in the room. For the next two-and-a-half hours, the innovators fielded difficult questions and absorbed valuable feedback during 30-minute "impact" sessions that took advantage of the council members' insights and experience. The sessions were tiring yet energizing, challenging yet encouraging. Above all, they were necessary to give the innovators their best shot at changing the world.

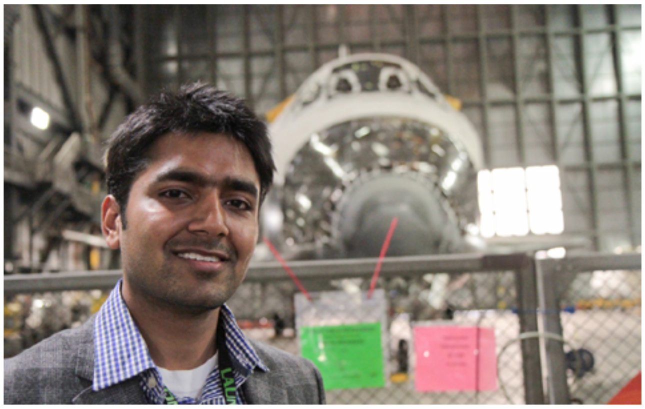
Where Ideas Take Off

Too often forums and conferences are structured inefficiently. The agenda often distracts from the most productive part of these two- or three-day events: the conversations that happen outside the ballroom in bars and over dinner. LAUNCH created the environment in which these conversations could take place during the day.

Two days before the event, the innovators were coached on how to give a short talk that told a compelling story for their morning presentations. The format resembled a TED talk. The innovators had less than twenty minutes to convey the genesis of their innovation, how it worked, why it mattered, and what they needed to fully realize it. The remaining time was left for questions.

The afternoon sessions resembled the after-hours talks that take place over a cocktail—only more intense and focused. The innovators shared their strengths and weaknesses with

LAUNCH council members listen to innovator presentations at the LAUNCH Energy Forum. Photo Credit: LAUNCH.org | Dennis Bonilla



Yashraj Khaitan, LAUNCH innovator and CEO of Gram Power, in front of Endeavour. Photo Credit: LAUNCH.org | Dennis Bonilla

the council members, and in return they received feedback: "Have you considered a joint venture?" "Your innovation seems to have applications outside of what you're proposing. Have you considered them?" "I think you have a great idea, but I don't see how you're going to turn a profit." "Have you considered outsourcing the manufacturing to another company?" "I have a contact who is looking for someone like you. I'll make the connection."

The sessions provide the innovators with an overwhelming amount of recommendations, advice, strategic direction, and ideas. The next challenge will be to chase down those opportunities in the months after the forum.
"To innovate is a human-to-human interaction," said Jacobson. "When we get into a room with a lot of high-quality people, those interactions go up by factors of ten. The ideas take off."

"Virtual Eavesdropping"

The forum reached beyond the walls of OSB II at Kennedy. The talks were streamed live via NASA TV and USTREAM. (The video will be posted soon to Vimeo and YouTube.) Key updates, images, and insights were captured, tweeted, and re-tweeted through the official LAUNCH Twitter account, **@launchorg**. A hashtag, #LAUNCHenergy tagged the ongoing conversation. If someone wasn't physically present, they could be virtually present.

The afternoon session conversations were captured using an application called MindMapr. Still in its beta test, the tool was operated by designated note takers who followed each innovator from table to table.

The conversations were recorded and displayed in the form of "Twitterfalls" and word clouds on the many television screens around the room. The result was a sort of "virtual eavesdropping" as Beth Beck, Space Operations Outreach Program Manager at NASA and LAUNCH organizer, described. It was possible to know what was happening across the room without actually sitting at the table.

Similarly, it was also possible to get a flavor for the conversations happening without actually being in the room. Through these online outlets, an entire community of virtual participants became part of the unfolding stories of the LAUNCH forum.

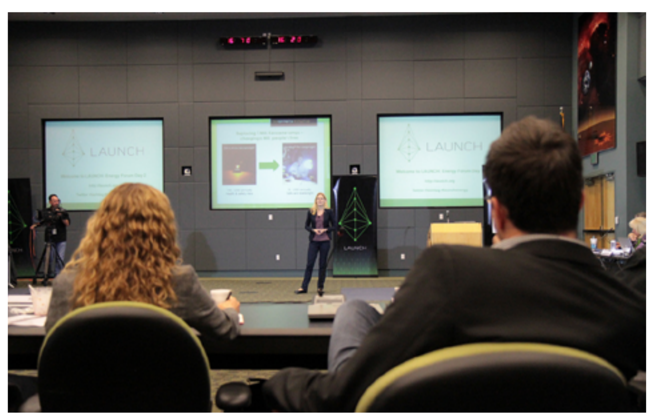
To Whom Much Is Given…

"To those whom much is given, much is expected," said Mikkel Vestergaard Frandsen, LAUNCH capacity and resource partner and CEO of Vestergaard Frandsen, quoting President John F. Kennedy. The forum was only the beginning. It is called LAUNCH, after all. Unlike usual forums where it ends and everyone goes home, the LAUNCH innovators have work to do. Armed with the valuable insights and advice from the impact sessions, the innovators will receive individual support from the LAUNCH team to integrate and act on the recommendations they received.

As the forum came to a close, it was apparent that a community was forged with the intention of leveraging "collective genius for a better world." "For NASA, LAUNCH is about sharing the sustainability story, share its problem-solving expertise with innovative problem solvers from around the world, and promote transformative technology to solve the problems that we share as global citizens of this planet," said Beck. "This may also address issues of long-duration life in the extremes of space."

"It's been three months since we came into existence," said Yashraj Khaitan, LAUNCH innovator and CEO of Gram Power, "but it's after these two days that I really feel like we've launched."

Follow **@launchorg** or #LAUNCHenergy on Twitter to be a part of the unfolding story.



Nina Marsalek, LAUNCH innovator and COO of The Solanterns Initiative, presents to the LAUNCH council. Photo Credit: LAUNCH.org | Dennis Bonilla

Chapter 5

Young Professional Briefs

Jennifer Keyes

January 31, 2011 — Vol. 4, Issue 1

An offhand response landed Jennifer Keyes a chance to work at NASA, leading to ten years of unexpected opportunities.

"I want to be an astronaut."

Jennifer Keyes, a systems analyst and engineer at NASA Langley Research Center, showed all the signs of having an engineer's mind at an early age. She took water measurements and surveyed plots of land with her father, a hydrologist. She drew out detailed assembly instructions for family campsites on vacations. She dismantled and re-assembled everything that captured her interest.

A trip to Space Camp during her senior year of high school opened her mind to the possibility of becoming an astronaut if she studied engineering. The next fall she started as a freshman at Rensselaer Polytechnic Institute (RPI), majoring in Aeronautical and Mechanical Engineering. That spring a career development counselor asked her what she wanted to be when she grew up. "Being a smart-aleck freshman," recalled Keyes with a laugh, "I said I wanted to be an astronaut, but meanwhile, working for NASA would be cool."

To her horror, the counselor made a few calls to contacts at NASA's Langley Research Center. A few weeks later, she had the opportunity to apply for an internship, and wound up with her first position at NASA.

Systems analyst and systems engineer Jennifer Keyes. Photo Credit: NASA

A Four-Year Interview

For her summer internship, Keyes coded for lidar data that had come back from the STS-64 Space Shuttle Discovery **Lidar In-space Technology Experiment (LITE)**. She was given the chance create plots from data that had never been made before, "which was tremendously cool to me," she says.

Within a matter of weeks after she finished her internship, Keyes returned for what would be the first of four co-operative (co-op) positions at Langley. During the first, she interviewed with project leads to determine which project suited her best. She chose to work on data analysis of a temperature-sensitive paint wind tunnel test with an aeronautical engineer named Ken Jones. "I started out

The Lidar In-space Technology Experiment (LITE) in the foreground on STS-64 Space Shuttle Discovery. Photo Credit: NASA/Johnson Space Center

in subsonic aerodynamics, looking at the flow of air over the airplane wings," she says. Jones challenged her with material she had yet to learn in her aeronautics engineering classes and took the time to explain to her how the material would apply to her schoolwork.

Her co-op experiences led her into a number of fields. "There was something new and exciting to do every day," she says. She worked in atmospheric science for a while and wrote data analysis code for an A-band spectrometer, performed systems analysis where she reviewed proposals for small spacecraft, designed "Tumbleweed" rovers for Mars, and wrote flight code for a successfully launched sounding rocket that blew off a nose cone so that the instrument could see into space.

As she neared graduation from college, a job opening at Langley in systems analysis became available. She jumped at the chance. A year earlier or a year later, she said, she might not have gotten the job. But her experience paid off. "I happened to be in the right place at the right time," she said. "I had a four-year interview."

Mentors and Shadowing

Always the engineer, Keyes initially thought finding a mentor would be a data-driven process. With three prospective mentors to interview, she approached each armed with intelligent questions designed to elicit interesting answers that would guide her towards a mentor-mentee match. "That was going to be my deciding moment."

But it wasn't. "It was completely a gut feel," Keyes says. Sitting in the office, of Laura O'Connor, technical assistant to the center director, she observed a different kind of data output than she had expected. "I was just sitting in her office and it just felt really natural to talk to her." Some people want mentors who hold positions they aspire to have one day, but not everyone needs that in a mentor. "I wanted to be able to talk out hard situations." O'Connor fit that role.

O'Connor's mentorship led to an opportunity for Keyes to shadow Langley Center Director Lesa Roe. "I was completely amazed at her ability to have a conversation with everyone," says Keyes. One minute Roe would be talking political strategy with a project manager, and then she'd seamlessly switch gears to have a technical discussion with a scientist. If Roe didn't know someone, she made a point to get to know them, added Keyes. "You can tell she's storing the information away so she knows who you are, where you came from, and how you got to where you are."

Listen, Try Everything, and HOPE

After 10 years at NASA, Keyes has two pieces of advice for young professionals: listen and try everything. She readily admits she's terrible with date memorization (much to the dismay of an earlier mentor, her U.S. History teacher Mr. Thomas Madson), but she appreciates learning the story behind a place, a people, and a culture.

"[History] builds the foundation for the advances in aeronautics, exploration and science that will come in later years," Keyes once wrote in an online forum. She takes every opportunity to learn more about her center and the agency through everything from tours to participation in an archeological excavation at Langley during a construction project. But it's the stories people share that she finds fascinating. She remembers listening to one of her colleagues talking about how cool Alan Shepard's car was. Suddenly it dawned on her: "Holy smokes, this guy actually knew Al Shepard!"

"I try to listen as much as I can," she says. "I wish I could do a brain download on some of these guys because they're going to leave someday, and I don't want that [knowledge] walking out the gate with them. I don't want it to leave in their heads and never have gotten captured."

Trying everything leads to unexpected pieces of information or contacts that will help later on, says Keyes. A recent task involved extensive work with the international community, and now she wants to learn more about the financial side of things. "It (NASA) all runs on money, and it sure doesn't

The 14 x 22 Subsonic Wind Tunnel at Langley Research Center. Photo Credit: NASA/Sean Smith Credit: NASA make sense to me sometimes." She hopes to gain a better understanding of the process of mission support and procurement to further her own experience and knowledge. Currently, Keyes works as a systems analyst in the Constellation of Earth Observing Satellites (CEOS) office at Langley. She is also the systems engineer for DEVOTE, a project designed to develop instruments and modify two Langley research aircraft for future science missions. DEVOTE is part of **Project HOPE (Hands-On Project Experience)**, a collaboration between the Science Mission Directorate and the Academy of Program/Project & Engineering Leadership that gives a project team the opportunity to propose, design, develop, build, and launch a suborbital flight project over the course of a year. Her team is currently finalizing its Level One requirements and success criteria for DEVOTE.

Keyes wears many hats. She tries to take advantage of every opportunity that comes her way, knowing in advance that not every one will be a perfect fit. "Some of them are a lot of work and I've realized they really were not the right thing for me," says Keyes. Even with those that end up being less than enjoyable, "it's just as important to learn that as it is to learn what you love." Keyes also aims to strike a balance between work and life by setting realistic goals and expectations. "I'll probably work on that for the rest of my life."

Luck and Preparation

Keyes's ten years at Langley happened through a series of fortunate events, from her last-minute change in college application strategy to getting a career counselor who had a connection at Langley. "I have been in the right place at the right time and surrounded by the right people ever since the very beginning," she says.

It hasn't been all luck. Keyes continuously prepares herself, both by trying new things and reading as much as she can. She also has developed a practice of self-reflection through journaling. A habit instilled in her during her year in NASA FIRST, she regularly writes three pages reflecting on how her day has gone.

"You can't get to the third page without having to deal with whatever issue is going on in your head." This ranges from finding a better way to work with someone, repairing a working relationship, or simply trying to understand fluctuations in her energy level at work.

Moving Forward

At 30 years old, Keyes hopes to have a long career ahead of her. Her initial dream of becoming an astronaut has not faded entirely. Ultimately, she wants to make a positive impact through learning from others and teaching those who come next. "I'm not sure what my path will be between here and there. I don't know what projects or activities I'll work on," she says. "I like to leave my options open since I've already had so many opportunities, most of which I never could have planned for or guessed would happen."

PM Challenge: Young Professionals Brief

February 28, 2011 — Vol. 4, Issue 2

The next generation of engineers and managers descended on PM Challenge to share stories and perspectives on professional development, open government, and international collaboration.

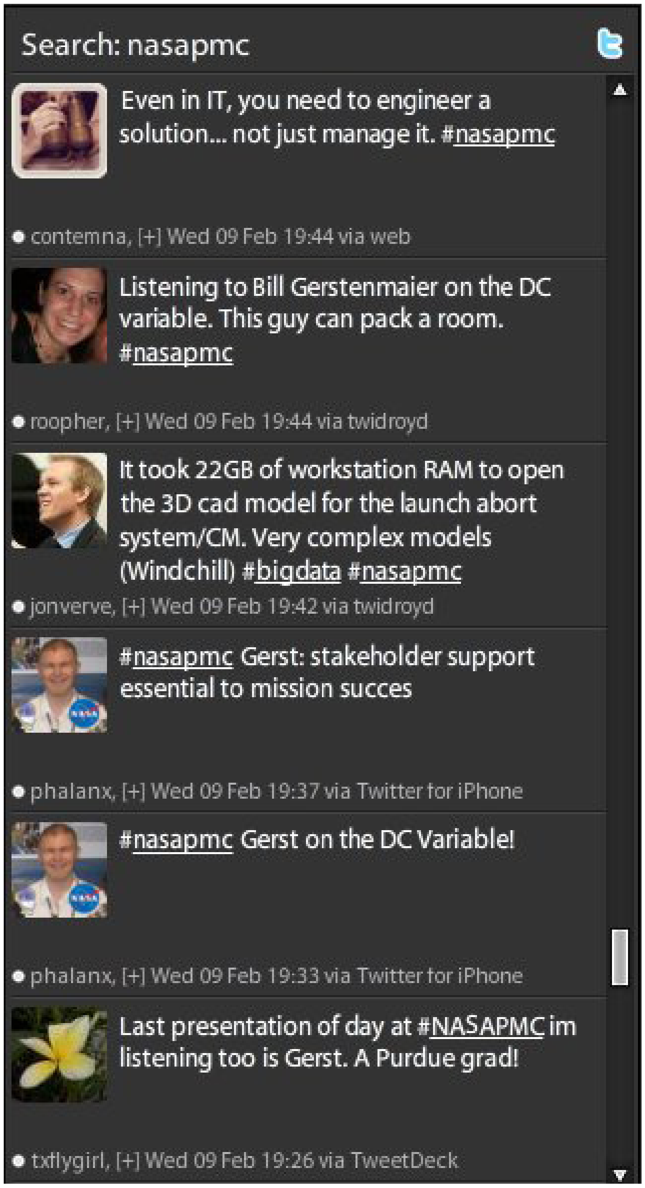
Above: From left to right: Sam Miller (Langley Research Center), Theo Muench (Goddard Space Flight Center), Gary Dittemore (Johnson Space Center), Kelly Currin (Kennedy Space Center), and Adam Harding (Dryden Flight Research Center) on a panel about developing new engineers at the 2011 NASA Project Management Challenge. Photo Credit: NASA APPEL

Young professionals from NASA, industry, international organizations, and academia participated in impromptu gatherings and formal presentations and panels at PM Challenge to gain insight from aerospace leaders and other young professionals about project management and the role of the next generation in the future of exploration.

In a panel on developing new engineers at NASA, five young professionals shared their thoughts on the importance of rotational development programs, access to and participation in lessons learned forums, career growth opportunities, and the importance of having the chance to fail. Each topic had a common denominator: having a good manager.

"A manager can make or break these opportunities," said Gary Dittemore, an integration engineer from Johnson Space Center. Dittemore started his career with nine other young engineers, and he is the only one still at NASA. Often it takes four or five years of experience to figure out whether or not you like your position, he said. Expanding the number of development opportunities like the **Systems Engineering Leadership Development Program (SELDP)** and exploring alternatives beyond the current options would benefit young professional development and retention, he suggested.

Theo Muench, an aerospace engineer from Goddard Space Flight Center, talked about the need for managers to convey the "why" of project requirements. He recalled working on a project where particles greater than 50 micrometers



Young professionals kept a running conversation going on Twitter during the two-day Project Management Challenge. Image Credit: NASA APPEL

in size were not allowed on the hardware. He later learned that the requirement originated from an incident where the pressure wave generated by setting a notebook down on a table shattered a component in the system. "It's really important to know how those golden rules and requirements are communicated to a developing engineer," he said.

Muench also touched on the importance of storytelling—that he experienced this while working with retired astronaut T.K. Mattingly. He recalled Mattingly telling him a story from his early engineering career. "He told me that story because he wanted to teach me a lesson. I didn't realize at the time, but essentially he was being a storyteller," he said. To all the seasoned engineers out there, he added, "You have the experience—become a storyteller."

Kelly Currin, a shuttle engineer from Kennedy Space Center, spoke on the value of "improving our technical training and encouraging rotational assignments." Managers who encourage involvement in hands-on learning opportunities and make meaningful work available over "check the box" development programs play an important role in retaining young engineers at NASA. Adam Harding, an aerospace engineer from Dryden Flight Research Center, added that establishing informal mentor relationships plays an important role. "Think about the members of your teams," he said. "Not just the leads, but also the ones in the trenches doing the work. Get to know them."

Learning through failure is essential to the development of new engineers, said Sam Miller, an electrical engineer from Langley Research Center. "You only have to do that once in a career and [you'll] never forget it," he said. "If an engineer can't fail, you're not developing them." When asked how the older generation needs to change in response to the next generation, he replied that large changes are not necessarily needed. "Change the way you interact, not the way you think."

In another session, Nick Skytland, a project manager at NASA Headquarters, and Lealem Mulugeta, a project engineer from the Universities Space Research Association, spoke about creating a culture of experimentation through **NASA's Open Government Initiative**. They emphasized that it's a process, not a single product. NASA has always been an open organization, as demonstrated by citizen participation, transparency with external stakeholders, partnerships, and efforts to improve internal NASA collaboration and innovation.

A shift is happening, they explained, in which emerging "citizen scientist" organizations are doing real science, engineering, and fundamental technology development. With a public following established, the next step is to develop an open and effective platform that will enable constructive contributions. "First, inspire. Then engage," Skytland said.

The final young professional panel during PM Challenge offered a more international perspective. Gene Bounds, senior vice president for the Project Management Institute, hosted a panel featuring Carole Hedden, special projects editor for Aviation Week; Stacey Edgington, a NASA official who also serves as chair of the workforce development and young professionals committee for the International Astronautical Federation; Justin Kugler, a systems engineer at Johnson Space Center; and Agnieszka Lukaszczyk, chairperson for the **Space Generation Advisory Council (SGAC).**

A 15.7 percent voluntary attrition rate among young professionals across the aerospace industry sparked the **2010 Aviation Week Young Professionals Study**, said Hedden. The study found that young professionals rate benefits, technical challenges, opportunities to advance, salary, and stability as most important when choosing a job. Stability in job location and the ability to start a family were overarching drivers for job selection. Young professionals

Above: From left to right: Eugene Bounds (Project Management Institute), Carole Hedden (Aviation Week), Stacey Edgington (NASA Headquarters), Agnieszka Luakszcyk (Space Generation Advisory Council), and Justin Kugler (Johnson Space Center) discuss developing the international young professional community at the 2011 NASA Project Management Challenge. Photo Credit: NASA APPEL

leave the industry because of poor relationships with direct supervisors, lack of flexibility, lack of variety of in daily work, lack of inclusion of ideas and contributions, and limited opportunities to learn new skills.

Hedden announced the initiation of a 20-year longitudinal study tracking industry young professionals. She looks forward to future research that will provide more international perspectives and insights about what information young professionals find is best transferred through specific media channels.

Kugler, an engineer who is a member of the newly formed NASA Forward organization, works to facilitate International Space Station research through non-traditional partners. He emphasized the importance of better articulating a vision of space exploration to NASA's stakeholders. He noted that his sister is an anthropologist. "What does space exploration mean to her? What about the kids that want to go work for Google or in biotech?" he asked. "We've struggled in some ways to articulate why what we do is important to everybody else."

Edgington shared her observations of young international professionals. She commented on her surprise when a young Korean engineer approached her at the International Astronautical Congress (IAC) last year and asked, "Can you tell me more about young professionals? We don't have such a thing in Korea." Not all young professionals self-identify, she said. She also noted that young professionals from United States tend to be much more outspoken, while those from other countries are more concerned with becoming a part of their company or agency. English language skills significantly affect involvement in international space activities. Edgington is looking for new ways to increase young professional involvement in the IAC.

Lukaszczyk, chairperson for SGAC, a volunteer organization consisting of over 4,000 members in over 90 countries, presented the challenges her organization faces. Obstacles like poverty, gender bias, access to technology, and lack of collaboration pose great obstacles for international space participation. "It's difficult," she said. "You have to prove yourself." She has had the opportunity to enable bright, young people without resources to get involved in space.

"You see the worth of your work immediately when you look at these people." Her goal, she said, is to leave the door of opportunity open just a bit wider than it was before.

Lealem Mulugeta

May 10, 2011 — Vol. 4, Issue 3

Lealem Mulugeta's journey from Ethiopia to NASA has led him to reimagine the future of space exploration as one in which anyone can participate.

Ethiopia to Canada

Born in Ethiopia, Lealem Mulugeta, was always picking things up and handling objects. "There was this side of me that was very creative and needed to build stuff," he said. Growing up, he used to watch his father, an electrician and mechanic in the navy, work around the house and imitate what he did. His father hoped he would become a doctor, but his true passion was flight. "That was the one thing that always fascinated me," said Lealem.

Lealem and his family moved to Canada when he was eleven years old. He planned to study medicine, but found he couldn't shake the allure of flight. "I started reading about spaceflight and different kinds of aerospace projects," said Lealem. "I found that aerospace engineering was the [field] that combined all of my talents into a nice package," said Lealem. He enrolled in the newly formed mechanical-aerospace engineering program at the University of Manitoba. While studying engineering, he trained as a competitive gymnast and worked as a research assistant in a metallurgy laboratory where he helped conduct research related to material processing in microgravity.

During this time he also got involved in Mars analogue research with the Mars Society of Canada. He "flew" two

Lealem Mulugeta standing in front of Yuri Gagarin's capsule in Moscow, Russia. Photo courtesy of Lealem Mulugeta missions, one of which he commanded, another where he was an engineer. “When I went through all of that I discovered I was really interested in engineering, but I also had this fascination on the human aspect of it.”

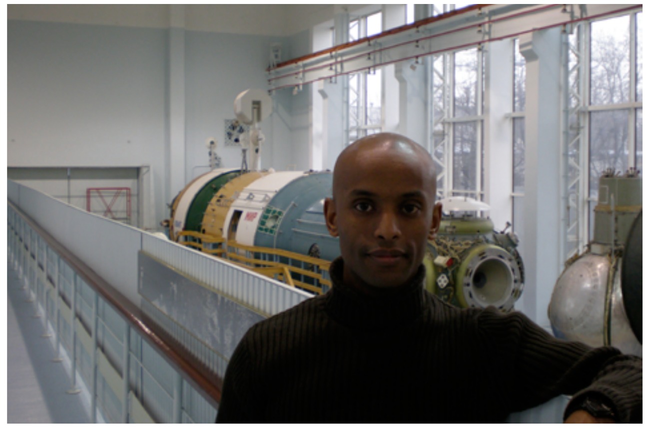
This led Lealem to pursue an interest in spacesuit design. The field offered many challenges related to materials technology and had the added bonus that his medical interests were applicable. “That’s really where I merged my engineering background and my interest for space life sciences together.”

Canada to France

Lealem wanted to work in human spaceflight, but his path was unclear. He considered a master’s in metallurgical engineering, but decided his heart wasn’t in it. Instead, he started working on mechanical design for a local aerospace company that developed satellite and aircraft hardware. He gained experience as a lead engineer on a small project with the satellite division and transitioned over to aircraft work, but it wasn’t spacesuits. “Everything I did there, I focused all of my design experience towards how I could transfer it to spacesuit design,” said Lealem. After a while, Lealem decided that he wanted more and left for France.

He went through the one-year master’s program at the International Space University in Strasbourg, France. The program supplemented his technical knowledge while also

Lealem Mulugeta performing an EVA at the Mars Desert Research Station in Utah. Photo courtesy of Lealem Mulugeta.



Lealem Mulugeta standing near the MIR Mockup in Moscow, Russia. Photo courtesy of Lealem Mulugeta.

fostering the ability to follow his curiosity about space life sciences. “The internship was a gateway for me to access experiences that I would have otherwise not had access to.” This included multidisciplinary work, cross-cultural experiences, and an internship opportunity with the EVA Physiology, Systems and Performance Group at Johnson Space Center in Houston, Texas, where he gained experience and expanded his network.

After his coursework and internship were complete, Lealem returned to Canada for eight months to perform independent research. He took it upon himself to publish as much as he could, which turned out to be five papers within that timeframe. The time also allowed him to reconnect with people he had met in Houston. It was only a short time before they invited him to come down and work.

Mooer’s Law

Lealem achieved what he had wanted since he was a boy: space, engineering, and life sciences all in one job. He currently works for Universities Space Research Association (USRA) as the project scientist for the **NASA Digital Astronaut Project (DAP)**. The DAP develops and implements computational physiology models to beneficially augment research to predict, assess, and mitigate potential hazards to astronaut health during spaceflight. His work has also sparked another interest: free data. “My passion for open data is an activity that I’ve taken on outside of my cool job,” he laughed.

Mooer’s Law (not to be confused with Moore’s Law) states that information will be used in direct proportion to how easy it is to obtain. Lealem has observed this phenomenon within space research and hopes to bring about change. “If people don’t know that the data exists, they aren’t going to ask for it,” said Lealem. “It gets locked away, nobody talks about it, people forget about it, and nobody requests it.”

The process to obtain space data is not impossible, but it is challenging. Currently the process to acquire raw data is complex and lengthy. The primary concern about releasing medical data in a timely fashion has to do with confidentiality.

While this concern is justified, he hopes to help modify the research process by incorporating "open" data requirements to make the data more widely available. "For example, if there's data that is not sensitive, you can talk to your subjects about it," he explained. "If they agree, then you release the data instead of locking it away and expecting people to look for it."

According to Lealem, there is a large community of researchers who would love to have more readily available access to NASA life sciences data to discover innovative medical treatments that can be used here on Earth as well as in space. "They might be able to do things with it that we might not have thought of," he said.

Global Impact

Lealem would love the opportunity to be an astronaut, but for now he hopes to contribute to shape sustainable, participatory space exploration. "I have this dream of having an impact at the global level," he explained. His ultimate vision includes a large-scale project that utilizes data or expertise that is freely available in a totally collaborative form.

A citizen scientist project called Zooniverse serves as one source of inspiration for this vision. Lealem explains that the "genius" in what they have accomplished is because of their ability to "leverage the common person to help them do things they just don't have the time to do." Lealem would like to see space agencies around the world take advantage of the public's common curiosity. "They are winning the support of citizens around the world with the work they are doing."

"The amount of innovation that is required to advance us to the next level cannot be achieved by any one nation. It's going to be multiple nations," he said.

Mouse Management: Taralyn Frasqueri-Molina

June 14, 2011 — Vol. 4, Issue 4

At the request of her manager, Taralyn Frasqueri-Molina opened the first page of the PMBOK™, holding a highlighter and pencil. She was going to change how her group did work.

Taralyn Frasqueri-Molina, or "TL" as she is often called, is a young project manager at the Walt Disney Animation Studios in Burbank, California. She oversees media technology projects that shape and optimize work environments for Disney animators. Ask her about project management today and she'll explain its importance in a way that takes you on an adventure. Five years ago, she might have given you a blank stare.

When she arrived at Disney in 2005, the Media Engineering Department was fun, but disorganized. Schedules slipped and costs increased. Her manager, Ron Gillen, was almost

Taralyn Frasqueri-Molina is a project manager at the Walt Disney Animation Studios in Burbank, California. Photo courtesy of Taralyn Frasqueri-Molina

a year into his new position and determined to fix the problem. He asked Frasqueri-Molina to "tame the chaos" of the scheduling department. As lead of the two-person scheduling crew, she reshaped the process so rooms were no longer double-booked, equipment showed up when it was supposed to, and support crew was available as needed. Frasqueri-Molina succeeded to the point where she engineered herself out of the job.

But even with scheduling on track, it didn't seem to fix the department's problem.

Gillen gave her a new job: media resource supervisor. If the problem wasn't the scheduling, perhaps it was the people and the equipment. She managed the distribution of media equipment (televisions, microphones, and other audiovisual gear) and the people responsible for setting it up. The staff seemed to work well. Yet, even with things going smoothly, the department's problems still persisted.

"We had these initiatives that had a specific start and end date, and we couldn't seem to get them done," said Frasqueri-Molina. This led her group to conclude that a lack of project focus might be the heart of their problem. Gillen approached Frasqueri-Molina a third time. "I hand you something and you seem to fix it. I hand you something else and you seem to fix it. So here's the PMBOK™. Fix it," Frasqueri-Molina recalled him saying.

"It was the end of 2006 when he handed me this big, strange book with words I'd never heard before," she said. It was the Project Management Institute's Project Management Body of Knowledge (PMBOK™). She read each line of the 450 or so pages of the PMBOK™, and she did everything it told her to do. "It was like throwing a giant net to catch a minnow," she said. "Over time you think, 'OK, that was unnecessary—not useless, but perhaps too much.' We didn't really need to be that robust, but we needed to start standardizing projects." As time went on, Frasqueri-Molina honed the management process. What worked for individuals? What worked for the team? What did they like? What didn't they like? Once she and her colleagues figured that out, things started to work

With Cinderella's castle in the background, the seven STS-118 crew members march down Main Street at Walt Disney World's Magic Kingdom theme park. Photo credit: NASA/George Shelton

really well. Sometimes this meant slowing the process down a bit, which didn't sit well with everyone in her department. She learned the value of taking the time to explain the method behind the perceived madness. "This is what was happening in the past, and it didn't work, this is why we're doing it this way now," Frasqueri-Molina would tell colleagues. "What do we have to lose?" She didn't intend to squash enthusiasm, creativity, or energy; she just wanted to get the job done right.

Frasqueri-Molina and her department found a way to see not only how their individual work fit into the bigger picture, but how their technology group collectively fit into the rest of the animation company. Along the way, she evolved into a project management enthusiast. "I've come from this sort of primordial, chaotic ooze."

Telling the PM Story

At a company powered by imagination, creativity, and a dash of pixie dust, infusing project management into its work might seem anathema to the Disney way. Not so. The company's famous "blue sky" thinking lets its artists and engineers explore every curiosity, every possibility, and improbability, before project managers get involved. While this might be viewed as stifling, project management serves to streamline the creative process into a deliverable product. It brings order to a chaotic process.

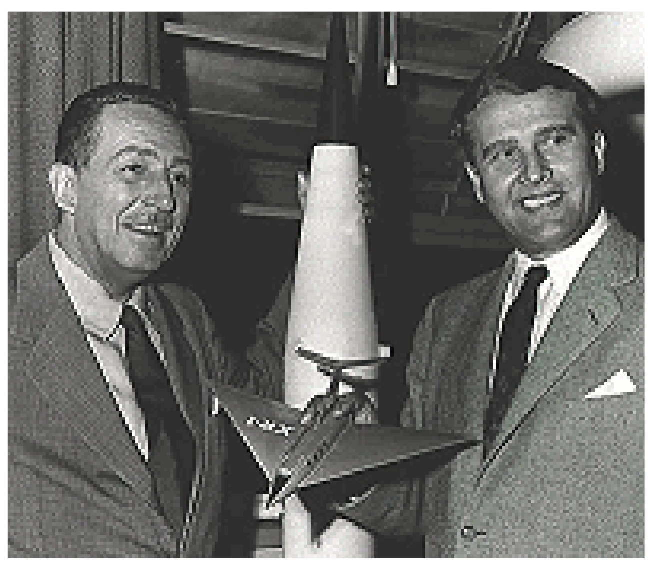
"There have been people in history who have built amazing things, most likely using some sort of process," explained Frasqueri-Molina, listing off marvels like the Parthenon, Colosseum, the Hanging Gardens of Babylon, and the Pyramids of Giza. "I don't think they used Agile, but if they did they didn't call it Agile," she said. "These amazing feats of engineering were created by somebody who was running the show and had to deal with workers, risks, and bring in the money, perhaps from a rich patron."

Frasqueri-Molina has created a first-of-their-kind workshop to tell this side of the story of project management to the Disney workforce. "Humans have been doing project management for thousands of years without a PMBOK™, Scrum, Agile, or RUP," said Frasqueri-Molina. "The idea is to get people comfortable with the basic, universal concepts that they already naturally understand. Everyone understands that in some cases, something must be done before something else can happen. In project management, we call that 'task precedence,' which helps create network diagrams. Those are just the technical terms for what you already do every day."

The idea for the workshop grew out of Frasqueri-Molina's experience during Disney's 2010 "Summer of Creativity and Innovation." The event was designed to get employees to network, try something different, and spark conversation and innovation. In the midst of her own department's transformation, Frasqueri-Molina had hoped to encounter something related to project management. She mentioned the absence of a project management outlet to Dan Davidson within the Learning and Development Department. The concept lingered until the following year.

When Molina presented at the **2011 NASA PM Challenge** in Long Beach, California, the response she got from the attendees brought the workshop idea back to the surface. "There seemed to be interest around being able to learn more about the good basic practices of project management," she said. She revisited the Learning and Development Department. The time was finally ripe for both parties to put the concept in motion.

She proposed the workshop, which is scheduled to pilot this fall, as a modest first step in a larger process toward creating a gateway into the world of the project management that would encourage the workforce to advance their management education. "What you're doing is starting to think about the skills you learn in the class and apply them to a larger scale," said Frasqueri-Molina. The workshop is not meant to prepare someone to walk up to NASA and declare they will manage the next Pluto mission. "You would be able to understand the language of someone in project



Wernher von Braun (right) poses next to Walt Disney (left). Photo credit: NASA management and what they're trying to accomplish. You'll see if project management is right for you."

"In essence, it comes down to understanding the fundamentals of project management and the structures," she explained. "Do you want your structure to be in the shape of a triangle? Do you want it to be in the shape of a square? Then you figure out what that means, what processes make up the inside. The structure should be somewhat custom made. Only you and your colleagues will know what is best for your projects."

For Frasqueri-Molina, fifty percent of being a good project manager is having the right attitude. "No structure, no fundamental understanding of the project management concepts, are going to help you if you don't have the right attitude," said Frasqueri-Molina. "Nobody's going to want to work for you, regardless of how amazing you are when it comes to concepts and structures of project management, if you're an unpleasant person. Your relationships to your stakeholders, how you interact with them, and how you understand them, that's the linchpin."

The Whippersnapper Cycle

Frasqueri-Molina was born into Generation X, but grew up with the Millennials. "I was all about cable television, microwave ovens, video games, and how technology was going to shape my future," she explained, noting that her coming-of-age moment was the late 1980s. "Michael Jackson was still walking around with the glove and red jacket. *ET* and *Return of the Jedi* were on the big screen." This notion of being on a generational "cusp" has made Frasqueri-Molina highly observant of generational differences in the workplace.

"Facebook might not draw somebody who was born in 1922. Whereas a place like Disney, that's been around for 90 years, has a very long history and will probably have those traditionalists because it's a long-time, stable, family company," Frasqueri-Molina said. While Facebook might not appeal to a traditionalist today, it may in the future. After all, Disney was once a "young, whippersnapping, upstart company," she pointed out.

Uniting generations through mutual understanding is central to organizational progress. "Millennials are just on fire," said Frasqueri-Molina. "They have to save the world and do everything right now." The energy and drive of Millennials is critical to progress, she stressed. "You cannot create the amazing things that really push our country and our generation to the next level without that whippersnapping generation. You need that next generation that will create that unexpected, unimaginable thing. That's their job, to create that unexpected, unimaginable thing because nobody else can do it. Only they can."

In her experience, inserting generational "cusp" people into a multigenerational group helps alleviate stark differences. Cusp people speak the language of two generations: the one they were born in and the one they grew up in. Frasqueri-Molina finds she has the ability to build a bridge between a Twitter-centric 26-year-old and a "phone-call-is-enough" 47-year-old. Everyone appreciates having his or her intelligence and genius recognized, explained Frasqueri-Molina. "That taps into something innate in everyone: the need to be a part of something, to be recognized. That, I think, is cross-generational. I've found that if I approach people that way— with a humble attitude that respects their contributions regardless of generation—it usually works out really well."

Follow Taralyn Frasqueri-Molina on Twitter (@PML33T)

Philip Harris

June 14, 2011 — Vol. 4, Issue 4

Two weeks on the job, Philip Harris walked into an office looking for something to do and walked out a project manager.

He Asked for It

"It was absolutely terrifying," Philip Harris, aerospace technologist for Mission Operations Integration in Johnson Space Center's Mission Operations Directorate, said about his new project management position. "I was expecting to be the worker bee on some project," he said, "expecting somebody else to be managing me." The next thing Harris knew, he joined the project management team for Johnson Space Center's ISS Live!, a large-scale, public outreach project scheduled to launch in the fall 2011.

"I didn't feel like I was ready for it at the time," recalled Harris. He'd managed small-scale projects in college, but nothing like this. Faced with unfamiliar technical work, schedules, deadlines, and cost, Harris was worried about what he didn't understand. Fortunately, he had support in place. Jennifer Price, the group lead who assigned him the job, was (and still is) available to answer questions, talk about the project, and help keep the team on track, explained Harris.

Philip Harris in the Mission Control Center at Johnson Space Center. Photo courtesy of Philip Harris.

Philip Harris in Neutral Buoyancy Tank at Johnson Space Center. Photo courtesy of Philip Harris.

Feeling comfortable with asking why things are done certain ways and getting good answers has also been helpful to Harris. "People actually take the time and have a discussion with me about why they do it this way versus the way you're thinking," he said. "There's been a lot of help along the way in just being able to understand the process not only at the technical level, but at the project management level."

From a Route Less Taken

Harris has an uncommon background for someone within the Mission Operations Directorate (MOD). He graduated from the University of Denver with a degree in Computer Science (CS), and he also studied Russian and Geographic Information Science. "I am headed in a different direction than most CS students for my career, and that is by design," said Harris. "I think that is one reason CS really brought me in—every discipline needs CS people, from humanities to engineers to lawyers to healthcare. It provides me with two great opportunities: I can work in a field that interests me and I also have the opportunity to engage in learning about a lot of disciplines to learn my job."

His path to NASA was even more uncommon.

The Role of Serendipity

Watching space shuttle launches at age three and having an astronaut visit his elementary school classroom sparked his enthusiasm for space exploration at a young age. That enthusiasm waned and then reemerged during his freshman year in college at the University of Denver, when he was working as part of the university's theater technical crew. Upon returning from a competition in Fargo, North Dakota, Harris spotted a man in an airport wearing a jacket with the NASA meatball on it. "I walked up to the guy and started talking to him about opportunities at NASA," said Harris.

The man with the NASA jacket, an engineer from Dryden Flight Research Center, gave Harris his card and told him to look into the NASA coop program. He returned to school and did just that. "I called pretty much every week for a long time until they got back to me, applied to each of the different centers, and got selected to go out to Dryden just before Thanksgiving of my sophomore year." In nine months, Harris went from Denver to his first NASA coop position in Edwards, California.

From Dryden to Johnson

With his sights set on joining mission control one day, Harris made the most of his coop opportunities. During his first coop experience at Dryden in January 2007, he worked with the range engineering group on the **Western Aeronautical Test Range (WATR)**; acted as an interface between the operations team and the test teams; and assisted with the integration testing for the Phoenix missile adapter for the F-15.

An opportunity arose halfway through his Dryden coop. He got a call from Johnson Space Center (JSC), where he had applied earlier. He interviewed, got the coop position, and transferred during the summer of 2007. He started working with the IT group on mobile workstations, encryption of flash drives, and setting up twelve-character passwords. ("It was good to work there because I understand the reason behind those now," added Harris.) During his second coop, he gained experience working on the onboard global interfaces and networks, and maintaining encryption systems for ISS. He got command certified and then moved onto work at the Neutral Buoyancy Lab, where he built configuration checklists for training events.

During his third coop at JSC he worked as an International Operations Liaison, interfacing with the Russian Federal Space Agency, Japanese Aerospace Exploration Agency, the European Space Agency, and other international partners to help ensure alignment of ISS operations, programs, and projects within the ISS. This experience complemented an undergraduate study abroad experience in Moscow during his senior year. Fascinated by the differences across cultures, these experiences sparked a desire to expand his understanding of program and project management at the international level.

Philip Harris standing in front of the Crew Compartment Trainer at Johnson Space Center. Photo courtesy of Philip Harris.

Professional Development

At age 24, Harris has grand plans for his career. "One of my ultimate career goals is to get one of the permanent change of station positions over in Russia," he said. In the meantime, he's taking every opportunity to learn and experience as much as he can.

Last April, Harris went through space station "boot camp," a six-week training event for new flight controllers that provides a generic overview of all the station's systems. Ultimately, when Harris goes into his specific discipline, this experience will provide foundational learning about how everything fits together.

He also has personal development objectives ranging from attending the Academy's **"Foundations of Aerospace at NASA"** course to completing a Master's degree in aeronautical engineering and participating in his center's leadership development program. He is currently at work on an online master's degree from the University of North Dakota's Space Studies Program, where he is focusing on international space policy.

Harris aims to maintain an interdisciplinary view throughout his career. "You can have all the technical knowledge in the world, but if you don't know how to write, analyze and understand other disciplines in other areas of the world, it's just not going to work out very well," he said.

Stacey Bagg

July 20, 2011 — Vol. 4, Issue 5

Stacey Bagg had her sights set on the slopes of Colorado when an opportunity to work at NASA changed her plans.

In the months leading up to her graduation from the University of Colorado at Boulder, Stacey Bagg, aerospace engineer at Glenn Research Center, handed out a few resumes to a handful of friends to circulate. She wasn't expecting to settle into a full-time job right away. "I was planning on being a ski bum," she joked.

She happened to hand a resume to a friend who passed it to the wife of a NASA contractor. "I got a call out of the blue the summer after I graduated from a manager up at Glenn Research Center," she said. The phone interview led to an onsite interview, which led to a job offer. She accepted. "NASA and Ohio were both a fluke," she said.

The Cutting Edge

Bagg started out as a test engineer at the Creek Road Cryogenic Facility. She did testing on liquid oxygen and nitrogen for liquid acquisition in propulsion systems. "In space you don't know where your fuel is," explained Bagg. "You can't always rely on it being at the bottom of the tank because you don't have gravity to put it there. Liquid acquisition is basically finding the liquid and making sure that only liquid goes into your engine when you turn it on."

Stacey Bagg, aerospace engineer at Glenn Research Center.Photo Credit: NASA

She also participated in mass gauging tests. "Again," explained Bagg, "in space, if you don't know where your liquid is, how do you tell how much you have?"

She worked for a contractor at the cryogenic facility for about a year before she had the opportunity to take a civil servant position. She's currently working on the Advanced Stirling Radioisotope Generator (ASRG). The engine is an electric power generator that runs on naturally decaying radioisotope fuel. The ASRG uses a quarter of the Pu-238 required for the older generation of radioisotope thermoelectric generators (RTG) that have flown on Viking, Cassini, Voyager, and other nuclear-powered missions. Like the RTG, the ASRG is ideal for long-duration missions in deep space – "anywhere where it's not going to be practical to use another power source like batteries or solar cells," Bagg said. "It's revolutionary technology compared to the current way of doing nuclear power."

Bagg's initial interest in aerospace was in the emerging commercial sector. "I didn't think I was going to work for NASA because of all the bureaucracy, but here I am," she

Stacey Bagg (front and center) and the 501st at Yuri's Night 2010. Photo Credit: Cleveland Yuri's Night said. While the bureaucracy is present, it's the work that keeps her around. Private industry is focused on the quickest, cheapest answer to solve current problems in the field, she explained. NASA is looking at the long-term, "out-there" ideas. "We're good at the cutting-edge stuff. The people in industry just don't have the time or the money to spend on these technologies," said Bagg. "We do the stuff that no one else can do. My current project is one of those. No one else can do this."

Bagg's excitement about her work is also fueled by what comes next. "We're trying to get new technologies into the field," she said. While she appreciates the tried and true technologies of the past, she looks forward to pushing the limits of today's capabilities with new, innovative products to move into the next era of exploration.

Starting out at Glenn

"When I moved halfway across the country, I knew absolutely no one in Ohio," said Bagg. However, during her onsite interview, she did have the opportunity to connect with the **Glenn Developing Professionals Club (DPC)**, a group that connects young professionals at Glenn through community service, professional development, and social networking. Similar to a college visit, a DPC representative showed Bagg around the center, and she had the chance to hang out with the group at one of their events.

"I met people very quickly through the club. I really liked what it did for me as a starting employee. When you get into your first job, you don't really have a lot of younger engineers around you." With the agency's average age hovering around 47, it's sometimes challenging to connect with coworkers who might have spouses, kids, or other commitments. "It's hard to develop that group up front when you haven't grown up here, and you don't know anyone when you're coming in."

Stacey Bagg working on the Advanced Stirling Convertor (ASC) hardware. Photo Credit:NASA/ Glenn Research Center

Bagg also started the Cleveland Yuri's Night - an annual, global celebration named for the first man in space, Russian cosmonaut Yuri Gagarin. Bagg attended Yuri's Night for three years in college and was surprised when she learned that there wasn't an event in Cleveland. "My first year at NASA, I started asking around about it. I figured, 'It's a NASA center, everybody should be way into this.'" Since then she has hosted three Yuri's Night parties in Cleveland, all of which drew crowds of 300 people.

Developing the Next Generation

"NASA has a lot of great programs right now, but we need more," said Bagg. "It's a shame to have people that really crave development opportunities be excluded from them." While there are development options, most are highly competitive and limited to a small number of slots. "What do you do with the rest of the people?" she asked.

In addition to leadership development and technical skills, policy and program/project management are also important to Bagg. She wants to understand the rationale behind key programmatic decisions, and she's concerned that valuable knowledge may be already walking out the door before next generation has exposure to it. "It's knowledge. Not just getting professional skills, but professional knowledge. That's what I want to see passed down."

She has had some extraordinary opportunities through the DPC, which she now chairs. Ray Lugo, who was deputy center director at Glenn when Bagg first joined, used to attend DPC book club meetings. "He would choose books for us that were along the lines of professional development such as influence or leadership," she explained. "When we discussed these topics with him, we would also discuss applications to the center or our own development, which was very cool."

DPC "work-area discussions," which resembled brown-bag lunches, gave Bagg an opportunity to see what else was going on around the center. "I could see across the lab what was going on in other areas, which is great because a lot of the groups don't interface intentionally."

Making the Connection

In addition to the DPC, Bagg is a member of NASA Forward. Prior to NASA Forward, her exposure to other young professionals across the agency was limited. "Forward is the first time that we've really had interaction between the very new professionals with other centers. Usually the first time you get that interaction is through NASA FIRST."

While NASA Forward is not yet as robust as programs like FIRST, it is a place for networking that has been challenging to do in the past. “It’s hard to communicate between different groups,” she said. “You just typically don’t do it because you don’t know a lot of people.”

She hopes that opportunities to interact, network, and connect with others across the agency will increase. Having these opportunities not only helps integrate the next generation of NASA, but also helps Bagg tap the expertise of her colleagues. Not too long ago, if she had a question about a particular piece of unfamiliar software, she wouldn’t know where to find an answer. Now, with a growing network across the agency, she’s able to reach out and ask someone, “Have you done this before?”

Darius Yaghoubi

August 30, 2011 — Vol. 4, Issue 6

In a time of transition at NASA, Darius Yaghoubi wants to learn as much as he can.

In the world according to television, if you work at NASA, you regularly don a white lab coat (horn-rimmed glasses optional) and pace around an office consisting of a chalkboard covered with complex equations and diagrams.

A large rocket probably sits on a test stand dangerously close to your window.

“People think it’s either that, or I go up to the rocket with a wrench and tighten bolts or something,” said Darius Yaghoubi, in an accent that betrayed his British roots. He also regularly gets asked if he is an astronaut. Neither a technician nor a crewmember, Yaghoubi, a twenty-seven-year-old launch vehicle control systems engineer at Marshall Space Flight Center, is a self-described “desk monkey.” Together with his team, he performs control and systems design analysis. This involves running computer simulations of launch vehicle trajectories and vibrational modes, making sure that the vehicles perform properly.

For the first three years of his NASA career, Yaghoubi worked on the Ares I Program. Since the cancellation of the Constellation Program, Yaghoubi has been working on projects related to the Space Launch System (SLS). He is part of a development team that is creating a FORTRAN-based simulation tool that will analyze the liftoff and separation dynamics of the rocket, and he is leading a team to modify an existing heavy launch vehicle model analysis tool. Even with all of the uncertainty surrounding the agency, “I’m happy to be doing some worthwhile work,” said Yaghoubi.

Connecting across Generations, Borders, and Centers

Connecting with his peers, communicating with more experienced colleagues, and learning from other disciplines is important to Yaghoubi. Seeking out and making connections with other young professionals – especially at a center with such an experienced workforce – has played an important role in his career and added to his sense of belonging to a community.

Last April, Yaghoubi attended the Academy’s **Masters Forum 20** in Melbourne, Florida. He appreciated the opportunity to step out of his world of rocketry and ponder **Howard Ross’s question** of whether a match would burn in microgravity, and learn about the **activities of international partners** such as Centre National d’Etudes Spatiales (CNES), the Indian Space Research Organization (ISRO), the German Aerospace Center (DLR), and the Japanese Aerospace Exploration Agency (JAXA). He also had the chance to network with young professionals from other centers.

“Prior to the forum, I didn’t really know too many people at the different centers. Since then, I know people at Dryden, Johnson, Ames, Kennedy, Goddard, and Headquarters,” he said. “I know a lot more people throughout the agency and I’ve been talking to them a lot more. At most centers I have at least one person I know if I need information.”

Yaghoubi observed that regardless of which centers the young professionals were from, they all enjoyed having the opportunity to make connections with one another at the forum. “We all had a great time in just being part of NASA,” he said. “We were all one NASA, and that’s all we really cared about.”

Darius Yaghoubi flying in his Cessna. Image courtesy of Darius Yaghoubi.

Darius Yaghoubi testing out an astronaut zero-g sleeping bag. Image courtesy of Darius Yaghoubi.

Sharing the Story

Yaghoubi is part of a young professional group at Marshall called 'Marshall Next.' Started in November 2010, group members regularly meet on their own time to achieve a number of goals, including community outreach, connecting with early-career hires, making Marshall an attractive place for future employees, and professional development.

Darius Yaghoubi in a crew capsule at the U.S. Space & Rocket Center in Huntsville, AL. Image courtesy of Darius Yaghoubi.

One of Yaghoubi's Marshall Next outreach adventures this past March took him to a Woodland Elementary School kindergarten class in Lafayette, Indiana. The wide-eyed, attentive four- and five-year-olds were ready to learn. "It was really interesting because I'm used to teaching college students, and here I am teaching these kindergartners about space, and they're asking me, 'What's the moon?'" explained Yaghoubi. After he quickly simplified his lesson for the day, the students made rockets out of straws and launched them with air pumps. They loved it. "It was really great to see that much passion in children wanting to learn about space, even if they are really young," he said. "It was awesome."

Sharing the NASA story extends beyond the kindergarten level, said Yaghoubi. This is another goal of Marshall Next. "If you work for NASA, you don't realize how little the general public knows about space," added Yaghoubi. "Most people think that the space shuttle goes to the moon." Effectively communicating what NASA does to a number of audiences is important – and often more challenging that most realize. "We're trying to help people understand what we do."

Learning Curve

In his fourth year at NASA, Yaghoubi is learning all he can from the rocketry giants at Marshall. Recalling the challenge of simplifying his explanations for kindergarteners, Yaghoubi said, "It's like I'm on the other end of that."
He has experienced a learning curve. "Lots of times you're just given a whole bunch of stuff to do and you don't have too much experience with it," he explained. "It can be good and bad—good in that it's probably the best way to learn things, bad in that it can take a long time to figure something out."

In the spirit of learning on the fly, he spends a lot of time on self-directed learning, mostly plowing through manuals and reading tutorials. He's had small whiteboard sessions during which he's learned more in two hours than in an entire semester. If he hits a wall, he talks to somebody for added guidance. "You have to have your own initiative to dive in and work through the problem yourself," he said. "There are people here who are smarter than I'll ever hope to be," he said. "They've always been really good whenever I have questions about things."

What Comes Next

"I intend to stay here (at NASA) as long as I can," said Yaghoubi. "It doesn't really get much cooler than dealing with the high performance technology that we work with here," said Yaghoubi. He enjoys working on cutting-edge technology and contributing to society in a meaningful way. Yaghoubi looks forward to the day when he becomes an expert in something and can share it with the next generation. "There are people who are still very interested in NASA and people still working towards the advancement of our space programs, even if they are fresh out of school and haven't been working here for years," said Yaghoubi. "We've got lots still to do."

A 1.9-second ignition test of the J-2X rocket engine is conducted on the A-2 Test Stand at NASA's Stennis Space Center. Photo Credit: NASA/SSC.

Jennifer Franzo

September 28, 2011 — Vol. 4, Issue 7

Mother of two, 27-year-old Jennifer Franzo loves a good rocket engine test.

Fire, Smoke, and Family

"Anytime we test an engine out here I think it's cool," said Jennifer Franzo. "Fire, smoke, even the science behind testing the engine is cool." Franzo, who just took part in a recent test in July on a J-2X engine, is a systems safety engineer at Stennis Space Center (SSC). Originally from Hattiesburg, Mississippi, Franzo works on fault tree and hazard analysis for the facilities at Stennis and the tests they will be used for.

"We look at any possible way that any failure could occur that would cause loss of mission or data, damage to the facility or test article, or injury to personnel." She looks at different types of failures and their causes. They range from a valve malfunction to an explosion to human error. With her team, she generates a hazard report for a particular test. "We come up with the controls and the verifications based on the requirements for the different causes and then rank those risks," she explained.

Now a mother of two (she just had her second child in August), Franzo was influenced by her career-oriented mother who instilled in her the determination to balance both work and family. "I have a wonderful support system," she said, referring to the support her husband and family provide her. "I never had a doubt in my mind that I could have kids, work full-time, and have a good job."

Mentors

Immediately after graduating from Mississippi State University, Franzo got a job at Michoud Assembly Facility with Lockheed Martin. "I came fresh out of school with this aerospace degree, didn't know what I was doing," said Franzo. Starting in 2007, her job was working on the External Tank. "That's all I wanted to do. I didn't really know what I was going to be doing, but I would be working on the shuttle program. That's what mattered."

Her supervisor and eventual mentor, Greg Lain, Senior Manager of Safety and Health, put her right into the deep end. Any angst or anxiety about working at NASA was quelled by one simple act. "He (Greg) believed in me," said Franzo. "That was one of the big things for me. He took me under his wing, showed me around, talked to me," said Franzo. "And then threw me to the wolves," she laughed.

Assigned to work on the Thermal Protection System Report (TPS), Franzo knew the gravity her assignment had on the program. "The Loss of ET Thermal Protection System" report is revised and edited after every flight of shuttle, Franzo explained. All inflight anomalies for the External Tanks were documented in the report and could potentially change the risk profile. After Columbia in 2003, these TPS reports increased in visibility.

"When I was given that report, Greg said, 'Here you go, you can do it. I have complete faith in you.' I remember thinking, 'This is a big thing. Don't you have a smaller one that you can give me? I don't know what I'm doing yet.' But he had complete faith in me and guided me."

Transition

During a recent opportunity to participate in a Masters Forum in Melbourne, FL, Franzo had the opportunity to hear the stories of seasoned practitioners from around the world about their experiences working on previous programs. "I enjoyed listening to the people who had been there from the very beginning of shuttle," said Franzo. In particular, she found the stories about transitioning from Apollo to shuttle particularly interesting.

During Apollo, the mission was clear: get to the moon. Wernher von Braun once explained, "Everybody knows

Jennifer Franzo at the STS-133 launch with her husband Drew Franzo and son Henry. Photo courtesy of Jennifer Franzo.

A remote camera captures a close-up view of a Space Shuttle Main Engine during a test firing at the John C. Stennis Space Center in Hancock County, Mississippi. Photo Credit: NASA/SSC

what the Moon is, everybody knows what this decade is, and everybody can tell a live astronaut who returned from the Moon from one who didn't." Things have since changed. "People see the end of the shuttle program and they say, 'What are you going to do now?'" said Franzo. She often finds it hard to communicate to her family and friends what is happening during this time of transition. "You know things are happening. You know we're moving towards something, but we don't have a clear defined direction yet," she said. "It's the end of [the shuttle] program, but it's not the end of human spaceflight."

Future Development

Stennis is the smallest NASA center. With roughly 250 civil servants onsite, Franzo sees the center's size as an advantage to her development goals. "You have no choice but to work with upper management because you're probably the only one who does the job that you do," she explained. "They know who you are and you know who they are. It allows you to get that face time, that one-on-one time."

Franzo's direct lead and mentor, Amy Rice, safety engineer for SMA, has been instrumental in her career development. "She has helped me mold myself into being more than just a systems safety engineer working on hazard analysis, which is what I came out here to start doing. My group here has given me the opportunity to expand and do other things." When she finds a class or training relevant to her career development, her department is supportive of its people learning as much as they can. She has been involved in STEP, a program sponsored by the NASA Safety Center, which allows engineers to gain added depth in their field. "You can choose whether you want to go into systems safety, quality, or reliability assurance." Franzo is also the point of contact for the Incident Reporting Information System (IRIS), an agency-wide reporting system that is used any time there is a mishap (e.g. explosion, fire, or someone gets injured).

One of her most memorable opportunities came about during STS-134. She was asked to sit in for her SMA director as the safety point of contact in the Launch Control Center at Kennedy Space Center. "It was always one of those things that would be so cool if you ever got the opportunity to do and how could you ever pass it up," she said. "It's just one of those things that makes you smile."

Networking the Next Generation

During the Masters Forum in Florida, Franzo had the opportunity to connect with other young professionals around the agency. "It made me feel like I'm not the only young person sitting here," Franzo explained. "It opened my eyes that there are a lot of young people who share my passion." Formerly part of a young professionals group at Lockheed dedicated to professional development, Franzo is looking to catalyze a similar movement at Stennis. She sees the importance of connecting with her peers at her center and around the agency.

"Everybody should have an opportunity to go see every NASA center they can because each one of them has something different to offer," she said. She has visited Johnson, Kennedy, and Marshall, which has helped her to see the bigger picture. "They all put the story together perfectly. From one center to the next you can actually see how all of the puzzle pieces fit together to make NASA what it is."

In addition to experiencing the culture each center offers, Franzo also believes that the next generation will unify under a common mission. "We are all engineers deep down. We need some sort of documentation that we are moving in a direction," she said. Talk is one thing, but to see things actually happening makes it real, makes it powerful. "I think there are a lot of young professionals who are willing to wait for a little while, but to keep us moving forward, we need to see things coming to fruition. We can't wait around forever."

Maciej Zborowski

October 28, 2011 — Vol. 4, Issue 8

Maciej "Mac" Zborowski is restoring the fuselage of a XFV-12A plane found in the middle of a vacant field so he can share its story with the public.

Mac Zborowski, 33, is an industrial design contractor at Glenn Research Center, who has worked on various projects since 2003. He moved to Ohio in 1986 from Warsaw, Poland. His background in industrial design and engineering has

XFV-12A fuselage on a dolly out at Plum Brook Station Image courtesy of Maciej Zborowski

afforded him the opportunity to do everything from working on planes, developing fuel-cell powered cars, to working as a photographer in Chicago. Currently he is working at Glenn's Power Systems Facility on a power beaming project. In his spare time, he has been dusting off a bit of history and share the story.

ASK The Academy: You've been volunteering your time with a cadre of others on a restoration project with the fuselage of a XFV-12A. What is it and how did you get started on it?

Maciej Zborowski: The XFV-12A is an aircraft that was developed here in Ohio by Rockwell International to take off vertically and fly at supersonic speeds. It was developed off a U.S. Navy contract in the '70s and early '80s. It was cancelled in '81 and somehow, part of the fuselage—the cockpit—was found by a friend of mine in the middle of a field at Plum Brook Station in Sandusky, Ohio, which is part of NASA Glenn Research Center. My buddy was working out there and he sent me a text message with a picture of this mysterious thing. Within two days we figured out that there was only one of these in the world and we have it. The director out at Plum Brook Station, General David L. Stringer, signed it over from scrap status into artifact status. So we got our Indiana Jones whips and hats, and we've been restoring it so we can show off Ohio's cool aviation research history.

Even though the XFV-12A was not a successful program, it shows you that just because you fail does not mean that you're failing at research. If you want to paraphrase Edison, it's not that you've failed 2000 times at making a light bulb, but you were successful at finding out that there's 2,000 ways of how not to make a light bulb, and just one to make one work!

It's a pretty neat little artifact to have in your portfolio, whether it's Ohio or the United States or NASA. The restoration is a great project. Sometimes research can be very nebulous to nontechnical people. It's one way of introducing someone to what research is and how it works.

ATA: Where is the plane fuselage now?

Zborowski: Right now it is in the old carpenter shop, basically in a small shack out in the middle of a field at Plum Brook Station. We've been ripping stuff out of it and making it kid friendly—removing sharp objects and sprucing it up. I've been taking a scrub brush to it and cleaning it. As soon as it gets painted, it will be sent to a museum or to other facility as an interactive exhibit. We're all doing this on a volunteer basis. To kids and people with some imagination, it's going to be the best thing they've ever sat in.

ATA: Your portfolio of experience is broad. As a practiced problem solver, how do you typically approach a new challenge or experience?

Zborowski: With a sketchbook! One of my favorite things to do is draw. When you get down to it, drawing to me is imaging the problem. Imaging the solution is fine, but remembering that solution or putting that solution into some kind of coordinate system, whether it is on a piece of paper or on a computer, that is where the magic happens. So I start out with a sketchbook, pencil, paper and lots of tea or coffee. When I have a new challenge given to me, I try to learn from it as much as possible to gain as much knowledge and experiences as I can.
Throughout the process of working on the XFV-12A I've learned a lot about different types of paints and surface treatments, and how different metals age. I've also learned that you shouldn't put your face next to a hydraulic hose that potentially has hydraulic fluid still in it from thirty years ago!

I've also talked to some of the guys who were involved with the testing of the plane at Langley Research Center. Some of the modeling and dynamics research was done here at Glenn, and then they shipped the XFV-12A off to Langley to test it on a big A-frame to see if it would hover. They also studied the dynamics of the Coandă effect.

ATA: What is the Coandă effect?

Zborowski: Pretend that you are in a car and you stick your hand out the window with all of your fingers pointing towards the front of the car, like an airplane kind of waving

Maciej Zborowski, an industrial design contractor at Glenn Research Center, stands in front of the fuselage of a XFV-12A plane that he is restoring. Image courtesy of Maciej Zborowski

XFV-12A on ramp at NAA in Columbus, Ohio Photo Credit: North American Aviation

your hand up and down out the window. Just like an airplane wing, but with your fingertips pointing towards the front of the car. The air rushing over the top of your hand naturally creates a low-pressure area above. If you start pointing your fingertips up, so that they're perpendicular to the road, there are eddies that come off your fingertips, and basically your hand stalls. It's the same thing that happens to an airplane if it stalls.

In the Coandă effect, the air going over the top of your hand would stick to your hand, essentially pulling it upwards. So no matter what angle you position your hand, it would not stall.

This was what made the XFV-12A special. It used moveable flaps in the wings and canard, to direct engine exhaust though the flaps and thereby causing the surrounding air to be directed in a different direction, all the while not separating or stalling from the surface of the flap. This thing looks like something from Battlestar Galactica. It does not look like a regular airplane you've seen. There's no vertical surface. It's a pretty weird looking airplane, especially for the 1970's. Fast-forward to today, the F-35 Lighting II is an airplane being developed by Lockheed Martin for the U.S. Air Force, the U.S. Marines, and the U.S. Navy. One of the F-35 models will take off vertically and also be supersonic. Imagine the fact that they were trying to do this in the '70s. They were barking up the right tree, they just didn't know of the ducting losses and airflow issues they would encounter. We're just getting around to solving that problem.

ATA: Why is it important to restore something like the XFV-12A?

Zborowski: I think that it's a prerequisite for working at NASA. Not only are we the best of the best, but we should take every opportunity that's sensible for us to interact with the public. If there's an opportunity that presents itself, we should be cognizant of that, run with it, and see where it goes.

When I found out about this fuselage being out in the middle of a field, waiting to be scrapped, and finding out that it's a prototype that is basically the definition of research, that's when a couple of us grabbed it by the horns and decided to go do something with it.

I will admit that it's been hard work. Plum Brook Station is about an hour away from Glenn. During the summer it was like an oven in the shop and certain parts are hard to come by. It's been tough work, but I think the end goal is pretty well worth it.

Chapter 6

Leadership Briefs

PM Challenge: Leadership Roundup

February 28, 2011 — Vol. 4, Issue 2

Agency and industry leaders offered their perspectives on innovation and mission success in an increasingly complex and constrained context.

Dr. Charles Elachi, Director of the Jet Propulsion Laboratory, kicked off PM Challenge by evoking the challenge and excitement of space exploration. Since Explorer 1 flew in 1958, he noted, NASA has been involved in a host of collaborative projects that have led to humans in continuous orbit for the past 10 years, a presence on Mars for 13 years, and 70 spacecraft throughout the solar system—all in the span of one lifetime. “Just imagine what can be accomplished in the next 50 years,” said Elachi. “I have no doubt that the future is going to be even more exciting.”

This year’s PM Challenge theme of “explore and inspire” is the reason Dr. Wanda Austin, president and CEO of the Aerospace Corporation, got into the business in the first place, she said. “There’s nothing like it. Even if you’re dead, it’ll get your heart going.” Austin challenged participants to think about how to get to the next level and what they would do differently tomorrow. Be real, be thorough, be honest and objective, be vocal, be careful, but be bold, she said. “That’s what you’re supposed to do differently.”

Associate administrator Chris Scolese spoke about the need to maintain a focus on technical excellence in the face of programmatic uncertainty and highly constrained resources. Drawing on historical examples such as the Panama Canal and the Holland Tunnel, he identified four key principles of technical excellence: engineering rigor; open and continuous communications; effective learning through training and development; and clearly documenting policies, standards, processes, and procedures. He emphasized the importance of reflection, and suggested that participants encourage their colleagues to attend events like PM Challenge. “We need to take time to learn,” he said.

In a leadership panel on risk management, Greg Robinson, deputy chief engineer at NASA Headquarters, posed questions to Bryan O’Connor, chief Safety and Mission Assurance officer; Mike Ryschkewitsch, chief engineer at NASA Headquarters; Bill Gerstenmaier, associate administrator for Space Operations; Mike Gazarik, newly appointed deputy chief technologist at NASA Headquarters; and Pete Theisinger, project manager for the Mars Science Laboratory at JPL, that sparked a discussion about risk and failure tolerances.

While no one wants to fail, failure brings to light unseen risk. Ryschkewitsch discussed the importance of designing robustness into systems to better tolerate risk. “Fundamentally [it is] the ability to tolerate off-nominal events,” he said. O’Connor highlighted the importance of defining a risk tolerance before a project gets started. “Redundancy is a way, not the only way to get failure tolerance,” he said. However, Gerstenmaier cautioned, redundancy also brings complexity. “That additional complexity might lower your overall ability to function,” he said.

“Failure could have been tolerated in the sense that it wouldn’t hurt a mission,” said Gazarik about his experiences working on the Inflatable Reentry Vehicle Experiment (IRVE). “The key would be that we would learn something from that experience.” Tolerating failure is difficult with “the searchlight on the mission,” he said. The Mars failures caused the program to restructure itself, but didn’t cause it to collapse, said Theisinger. He noted that Mars Science Laboratory faces similar challenges. “They’ll forgive you for bad karma,” he said, “but they won’t forgive you for being stupid.”

PM Challenge: Executive Behavior Panel

February 28, 2011 — Vol. 4, Issue 2

Four senior NASA executives shared what it means to step away from their technical roots and move into an executive position.

Chris Scolese, associate administrator at NASA Headquarters, and Bill Gerstenmaier, associate administrator of Space Operations, faced a leadership challenge when a pinky-sized poppet fragment cracked off during the ascent of the Space Shuttle Endeavor in 2008. Once the shuttle and crew returned safely, focus shifted immediately to the upcoming STS-119 mission. With a tight launch schedule, no understanding of the problem, and no appointed NASA Administrator accountable for keeping stakeholders informed during the Presidential transition, the agency could not afford to fail.

Scolese and Gerstenmaier took the initiative to build an informative relationship and rapport with their stakeholders, which helped to avoid a political backlash during the Presidential transition. "A little bit of action early in the problem pays big dividends," said Gerstenmaier in a panel discussion that examined the factors that determine executive success at NASA.

Christine Williams, director of the Systems Engineering Leadership Development Program at NASA Headquarters, hosted the panel, which featured Langley Research Center Deputy Director Stephen Jurczyk and Goddard Space Flight Center Director of Engineering Dennis Andrucyk in addition to Scolese and Gerstenmaier.

Taking on an executive position often means leaving one's technical expertise capability behind. But, said Jurczyk, "it's not about your personal success…it's about the team's contributions, building the team." Jurczyk said that he sits on review boards to get his technical fix. Gerstenmaier shared this sentiment. He now finds joy in watching teams rise to the occasion and finding new and exciting challenges for others to tackle. "It's hard to give up the technical side," he said. "I'm a recovering engineer."

Constant, clear communication in an executive position is imperative. "We have to remember that what we're doing, we're doing it for the first time," said Scolese. Shielding individuals from bad news or potential road blocks is counterproductive. "You have to be appreciative of bad news," added Gerstenmaier. Create a culture where it is safe to bring up new ideas. If it is perceived that individual opinions will be rejected, the system shuts down fast, and you run the risk of not knowing what you need to know, he said. "All you have to do is shoot one messenger and you'll hear what people want you to hear," said Andrucyk.

Decision-making at the executive level reaches new levels of complexity. "We try to parse the problem into smaller pieces," said Gerstenmaier. Sometimes a good decision comes from knowing when not to act. "This doesn't mean that you don't make decisions," said Scolese. It means letting people go off and do their jobs. Trusting your people is critical, remarked Jurczyk. "In the end, it's not about being right, it's about understanding how to make your group or team successful."

An audience member asked the panelists how they address team or individual weaknesses, despite being surrounded by talent. Gerstenmaier responded that it comes back to openness. "Can you talk to your folks about the weaknesses you see?" he asked.

When asked if he wanted to become an executive leader, Scolese said he'd think about it. Technically focused in his early career, he felt fulfilled by his work at Goddard Space Flight Center. He took the weekend to make the decision, determining that moving up was worth trying. "Before you say no, really take some time to think about it," he said, "and try and decide that it may be worth trying your hand at it."

Bill Gerstenmaier on the DC Variable

February 28, 2011 — Vol. 4, Issue 2

Bill Gerstenmaier offered his perspective on how to work within the political context of Washington.

Bill Gerstenmaier, associate administrator of Space Operations, stood in front of a screen displaying an image of Capitol Hill with the International Space Station (ISS) in the background, which he said represented two things he'd come to know and love. He challenged the audience, especially its non-Washington members, to better understand what he called "the DC variable."

Gerstenmaier began with his version of Maslow's Hierarchy of Needs: technical excellence, safety culture, information flow, flight rationale, mission success. He then noted that stakeholder support grounds all of these elements. "Without that stakeholder piece underpinning all of these, we will not get to mission success," he said.

Gerstenmaier continued, noting that, "even defining the term 'stakeholder' is pretty tough." NASA's stakeholders are a diverse group that includes: the Department of Defense, the aerospace industry, National Science Foundation, Office of Management and Budget, Office of Science and Technology Policy, the White House, National Research Council, Congress, and the public, to name a few. With such a diverse group, NASA' s attempts to build consensus are complicated by the need for different messages for each stakeholder. "This is really what we're struggling with today."

"Do our stakeholders understand how difficult the things are that we do?" he asked. "Our goal has got to be for NASA to step back technically and realize what we really want to go do, take the best inputs from this diverse group, and build a plan that we can then show to everyone else," he said. "If we stay in a 'react' mode, where we are reacting continually to the stakeholders...We, NASA, have to take this diverse input, listen to it to the best of our ability and build a plan that we can then start taking forward...We will have to craft the best plan we can—it will not be a perfect plan—but put the best plan we can together and put all of these pieces together and go and try to execute it."

Dramatic changes in information and news circulate through blogs, and social media has impacted NASA greatly. While the initial reaction may be to control these outlets, Gerstenmaier has taken a different approach. It has not been uncommon for him to finish a Flight Readiness Review for the shuttle and have a report out about it before leaving the building. Instead of suppressing communication within the reviews, he has invited his public affairs officer to attend and tweet updates. Doing this has enabled him to tell a better NASA story and actually stay in front of the blogs. "Instead of trying to slow down communication, recognize that communication is diverse and fast. How can you now participate in it and use it to your advantage?"

An audience member voiced a concern about non-technical people making technical decisions for NASA. This is a challenge, Gerstenmaier admitted, but NASA can make an effort to stay in front of it. "You have to listen to them, but then you have to figure out a way to communicate to them in their own language," said Gerstenmaier. "You need to know your audience and who you're talking to." He emphasized the need to think about the real driver behind what they are trying to accomplish. "If we come in and we just expect them (non-technical stakeholders) to know exactly the way we're talking from our perspective, it won't happen."

Masters with Masters Features Human Spaceflight Leaders of NASA and JAXA

July 20, 2011 — Vol. 4, Issue 5

The International Space Station has taught us what it really means to engage in international collaboration, according to Bill Gerstenmaier and Dr. Kuniaki Shiraki.
Gerstenmaier, NASA Associate Administrator for Space Operations, and Shiraki, Executive Director of the Human Space Systems and Utilization Mission Directorate at the Japan Aerospace Exploration Agency (JAXA), shared personal reflections on the role of international collaboration in complex programs in a Masters with Masters training event at the James E. Webb Auditorium at NASA Headquarters on July 11, 2011.

Masters with Masters 9 featured NASA Associate Administrator for Space Operations Bill Gerstenmaier and JAXA Executive Director for Human Space Systems and Utilization Kuniaki Shiraki at NASA Headquarters on July 11, 2011. Credit: NASA APPEL

Gerstenmaier emphasized the importance of building trusting relationships over time among the International Space Station (ISS) partners. "We have a personal relationship where I can share what's really going on within the agency with my international partners so they can see the struggles that we're facing, and they can describe to us the struggles that they're facing," he said. "We realized that by really sharing things back and forth, we could actually help each other in a way to move forward."

Shiraki discussed the need for leaders to make decisions that address their own interests as well as those of their partners. He recounted how the planned shipment of JAXA's Kibo module to Kennedy Space Center (KSC) in 2003 coincided with the aftermath of the Columbia accident. After much deliberation, he decided to ship Kibo even though the shuttle was grounded indefinitely. "It…seemed good to show movement in the station program, that station was still moving forward even though Columbia was going on," he said. "I thought it would be beneficial to both Japan and to NASA that we made this move early."

Gerstenmaier pointed out that a lesson from the Columbia accident was the interdependence among the ISS partners. "As we go forward in future programs, we need to start with that concept to begin with. It's not separate pieces integrated into a whole," he said.

Shiraki stressed the need to learn about the culture, politics, organization, and processes of other space agencies. "We are trying to do things the way we do them in Japan, but there are different ways of doing [things] in NASA, and the first thing we have to do is learn the difference," he said. "What is the difference between what we are doing?"

Gerstenmaier said that after years of working together, the ISS partners have been able to transcend many of their differences. "We've bridged the gap and have our own culture—the ISS culture. But it only came after multiple years and multiple challenges of working with each other."
Both expressed excitement about tapping the full potential of the ISS's research capabilities over the coming decade. Shiraki focused on how the space station can improve the future and benefit humankind, noting that its utilization should "appeal to the world."

Masters with Masters events bring together experts to share insights, lessons learned, and best practices in a setting that promotes learning and discovery through dialogue.

MIT President Susan Hockfield on Innovation

August 30, 2011 — Vol. 4, Issue 6

Five underlying rules are critical to ignite the American innovation engine, according to MIT President Susan Hockfield.

In an address to the National Governors Association, Hockfield described the conditions necessary for innovation to thrive. Using the case study of Yet-Ming Chiang, an MIT alumnus and professor who also founded A123 Systems, a battery manufacturer for electric vehicles, Hockfield spelled out the roles that academia, industry, and government have to play in stimulating innovation:

- **Rule One:** Attract brilliant strivers and help them get all the education and hands-on experience they can handle.
- **Rule Two:** Scientists and engineers can make great entrepreneurs – but an entrepreneurial culture helps them flourish.
- **Rule Three:** Growing new ideas takes money – from the right source at the right time.
- **Rule Four:** Innovation clusters are powerful – and they get stronger as they grow.
- **Rule Five:** If we want to make US jobs, we can't just make ideas here – we have to make the products here.

Hockfield also identified some of the challenges ahead, including making higher education more affordable, reforming immigration, advocating for federally funded research, and building dense research communities supported by universities, business and government.

Chapter 7

Academy Bookshelf

The Ambiguities of Experience

January 31, 2011 — Vol. 4, Issue 1

Experience is the best teacher, right? Not so fast, says James March of Stanford University.

An organization such as NASA exists in an ever-changing context. To take a simple example, the management practices that enabled the agency to thrive during the design and development of the Apollo systems could not be superimposed directly onto the design and development of the Space Transportation System (the space shuttle). The organization's mission had changed. The programs' requirements had vast differences. Technologies had matured. The social context in which the agency operated also had shifted in ways ranging from the political environment to the composition of the workforce. As a result of these factors (among others), some management practices from Apollo were clearly still applicable, while others were no longer instructive.

How do organizations learn intelligently from their accumulated experience? In ***The Ambiguities of Experience***, James March of Stanford University examines the evidence and the folklore about learning from experience. March begins by noting that, "... although individuals and organizations are eager to derive intelligence from experience, the inferences stemming from that eagerness are often misguided." The problems, he says, "lie partly in correctable errors in human inference forming, but they lie even more in properties of experience that confound learning from it." In other words, experience itself can limit the ability to learn and adapt.

So what's an organization or an individual to do? In short, the best approach is to recognize the limitations of learning from experience. According to March, "Experience is likely to generate confidence more reliably than it generates competence and to stop experimentation too soon. As a result, there is a persistent disparity between the assurance with which advice is provided by experienced people and the quality of the advice."

Willful Blindness

May 10, 2011 — Vol. 4, Issue 3

Our unwillingness to see the reality surrounding us can have devastating consequences, according to Margaret Heffernan. In the years leading up to the financial meltdown of 2008, there were clear signs that something was seriously amiss with the U.S. real estate and housing markets. At the height of the boom, homes in some communities sold the day they hit the market for significantly more than the asking prices. Homeowners borrowed against the newly inflated values of their houses, confident that the upward trend would continue. Even people without jobs, incomes, or assets could get so-called NINJA mortgages (no income, no job or assets) and purchase homes costing hundreds of thousands of dollars for no money down. Industry veterans knew there was a problem, but many said nothing, eager to profit or, at the very least, not be left behind. "When the music stops, in terms of liquidity, things will be complicated. But as long as the music is playing, you've got to get up and dance," the former chief executive of Citigroup told the Financial Times in 2007.

In *Willful Blindness: Why We Ignore the Obvious at our Peril,* Margaret Heffernan examines this phenomenon in detail. Drawing on research about organizations, neurobiology, human behavior, and cultures, Heffernan explores the powerful forces that conspire to keep us from seeing what is plainly obvious to others. Our willful blindness originates, she writes, "in the innate human desire for familiarity, for likeness, that is fundamental to the ways our minds work." We are attracted to people who see the world the same way we do, and we seek confirmation of our ideas and beliefs in everything from the people we choose as friends to the news we consume.

Heffernan is careful to point out that willful blindness does not begin as a conscious choice:

> "We don't sense our perspective closing in and most would prefer that it stay broad and rich. But our blindness grows out of the small, daily decisions that we make, which embed us more snugly inside our affirming thoughts and values. And what's most frightening about this process is that as we see less and less, we feel more comfort and greater certainty. We think we see more——even as the landscape shrinks."

Organizations like NASA face unique challenges because of the complexity of their contracting arrangements, which Heffernan refers to as "the disaggregation of work." She recounts the network of organizations involved in the Challenger accident, noting the distance among the manufacturers of the O-rings, the suppliers of the plastic for the O-rings, and the decision-makers at NASA's centers who had a direct stake in the decision to launch the shuttle. The trend toward outsourcing has not always yielded the benefits that its proponents have championed. "In reality, the disaggregation of work has made it harder than ever to connect all the pieces; in fact, you need huge swaths of management to oversee outsourcing, competitive bidding, partnerships, and contractors," she writes.

One manifestation of the willful blindness Heffernan describes is a behavior that Goddard Space Flight Center Chief Knowledge Office Dr. Ed Rogers calls organizational silence. This refers to the reluctance of individuals to speak up either when they don't understand something or they know something is wrong. Heffernan cites a study by Elizabeth Morrison and Frances Milliken of New York University's Stern School of Business, which found that fully 85 percent of executives interviewed in a cross-section of industries felt at some point unable to raise an issue or concern with their bosses. The consequence of this silence, Heffernan concludes, is that "the blind lead the blind."

Industrial Megaprojects

June 14, 2011 — Vol. 4, Issue 4

Most megaproject failures "stem from a basic lack of being able to pursue a common goal with clarity and good behavior," according to Edward Merrow, author of *Industrial Megaprojects.*

Merrow, who has studied projects at the RAND Corporation and Independent Project Analysis (IPA) for the past 30 years, examines a dataset of 318 commercial industrial projects with budgets larger than $1 billion, most of which are in the energy or chemical sectors. What he finds is not so good: by his account, 65 percent of these projects are failures. (Merrow defines the thresholds for failure as: greater than 25 percent in cost overruns, cost competitiveness, or slip in execution schedules; greater than 50 percent in schedule competitiveness; and significantly reduced production into the second year of operations.)

He attributes the majority of these failures to seven key mistakes, some of which are specific to private sector projects (e.g., greedy behavior associated with profits). Most are common to projects in any sector: schedule pressure; inadequate spending in the early phases of a project; across-the-board budget reductions; misuse of firm-fixed price contracting arrangements and efforts to transfer project risk to contractors; and a tendency to fire project managers whose projects overrun greatly on cost. "I have yet to meet one [project manager] who starts the day by asking, 'What can I do to screw up my project?'" Merrow writes. "Large cost overruns on major projects can almost never be honestly laid at the door of the project director."

Merrow observes that successful megaproject managers typically share three qualities: they are generalists, politically savvy within their own organizations, and good communicators, "especially good at communicating upward," he notes. Most importantly, he says that project leadership depends on the ability to protect the team from external pressures:

> "Whether a megaproject leadership is able to hold the trust of the project team depends above all on its ability to insulate those at the working level from interference from outside the project. If people outside the project team do no cooperate with the project director, respect for his or her leadership erodes. Project professionals are willing to work on megaprojects because the projects themselves are interesting and exciting. If the leadership cannot keep the project momentum up, it is very difficult to maintain team morale."

While Merrow's analysis focuses on the management of private sector projects, many of his observations about teams, partners, front-end loading, project controls, and risk will interest project professionals in any sector.

Thinking Small(er)

July 20, 2011 — Vol. 4, Issue 5

Two new books examine the advantages of taking incremental steps to achieve big breakthroughs.

Conventional wisdom tells us that the only way to make a big impact is to think big and act accordingly. Not so, according to two recent books that offer counterintuitive advice about the advantages of "failing fast" and learning through controlled trial and error.

In the natural world as well as in organizations, failure is the norm rather than the exception, says Financial Times columnist Tim Harford. In *Adapt: Why Success Always Starts with Failure*, Harford looks at empirical research suggesting that organizational success and failure closely mirrors evolutionary biology. From this starting point, he identifies three essential steps for adapting successfully to a dynamic world: "...first, seek out new ideas and try new things; second, when trying something new, do it on a scale where failure is survivable; third, seek out feedback and learn from your mistakes as you go along." He names these three steps "Palichinsky Principles," after Peter Palichinsky, a Russian engineer with a love for statistical analysis. Palichinsky advised leaders ranging from the last Russian czar to Soviet premier Joseph Stalin to adopt a step-by-step approach to industrial planning rather than singular, massive initiatives. While history has borne out the wisdom of Palichinsky's analysis, his compulsive need to speak truth to power cost him his life.

The converse of the Palichinsky approach, Harford reminds us, is over-reliance on experts. He delves into a litany of case studies and research, including seminal work by Philip Tetlock on expert political judgment, and comes to the conclusion that, "...whether we like it or not, trial and error is a tremendously powerful process for solving problems in a complex world, which expert leadership is not."

In *Little Bets: How Breakthrough Ideas Emerge from Small Discoveries*, Peter Sims focuses on the importance of developing trial and error as a strategy, which he characterizes as one of placing little bets rather than big ones. Noting the connection to the creative process, he writes that, "...little bets provide a powerful vehicle to approach life and work in a new way." Sims moves through case studies ranging from the way comedian Chris Rock develops material to the making of a Pixar animated film to architect Frank Gehry's interest in nonconventional building materials.

The common denominator between *Adapt* and *Little Bets* is Brigadier General H.R. McMaster, who has won wide recognition for establishing an effective counterinsurgency in the Iraqi city of Tal Afar. Both Harford and Sims praise McMaster's willingness to buck conventional wisdom, run controlled experiments, and move in the direction of what works. McMaster's approach (as well as his tendency to speak his mind) has been widely documented elsewhere, so it's not surprising that he would turn up as a case study in two books exploring similar terrain. His story offers a powerful example of the principles that both books embrace. Reading Harford and Sims side by side may make a reader wish that each author had found more examples off the beaten path. *Adapt* provides more intellectual heft, while *Little Bets* is a breezy series of stories that drive home a common point.

CHAPTER 8

Research Briefs

Lessons for Space Debris

January 31, 2011 — Vol. 4, Issue 1

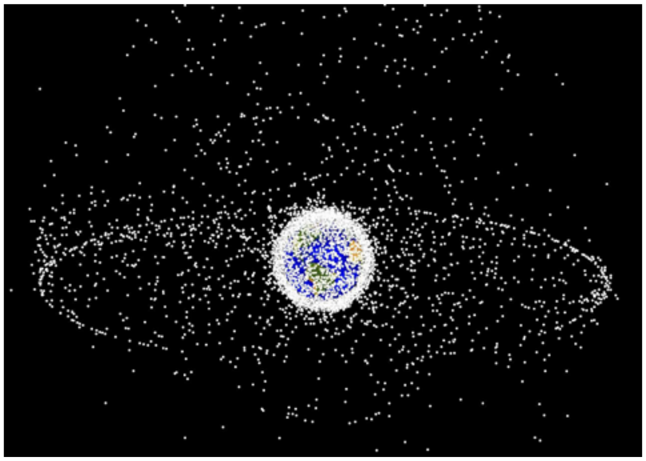
A recent **RAND study** recommends the development of remediation methods in addition to mitigation processes for orbital space debris based on lessons from nine parallel problem areas.

There are over 20,000 softball-sized or larger manmade objects orbiting the Earth. The numbers grow by four orders of magnitude if the count includes smaller objects the size of a dot. A recent report by the RAND Corporation seeks to provide decision-makers insight and context about the problem of orbital space debris by comparing it to similar problems outside of the aerospace industry. The study identified nine "orbital debris-like" problems: acid rain, airline security, asbestos, chlorofluorocarbons, hazardous waste, oil spills, radon, spam, and U.S. border control.

These comparable problems share the following behavioral norms with orbital space debris:

> Past and present behavioral norms do not address the problem in a satisfactory way.
>
> The risk of collateral damage is significant if the problem remains ignored.
>
> There will always be "rule-breakers."
>
> The problem will most likely never be solved because the root cause is difficult to eliminate.

The report focuses on lessons from mitigation (actions designed to lessen the severity of a problem) and remediation (actions taken to reverse an undesirable event after it has already occurred). According to the authors, the space community views orbital debris largely as a mitigation problem. However, they note, "...while everyone in the space community certainly agrees that orbital debris poses a risk, a lack of government and private industry funding for this effort suggests that the perception of risk has not yet crossed a critical threshold that would prompt demands for remediation."



Computer-generated image of objects in Earth orbit that are currently being tracked. Photo Credit: NASA/Johnson Space Center

The report proposed four considerations regarding the development of pathfinder remediation possibilities.

"A community must be prepared for 'shocks' or catastrophic events." Catastrophic events have occurred such as the Iridium/Cosmos collision. On-orbit collisions are likely to continue.

"Remedies must be designed and tested to work under actual operating conditions." The Deepwater Horizon oil spill showed that the remedies used during the first 40 days were insufficient because they had never been tested or proven to work in deepwater drilling conditions. Understanding technology performance under real working conditions is crucial.

"One remedy is not good enough." This is often seen in airline security, border patrol, and spam. All of these problems require multiple remedies to address the issue. Often, the development of one remedy will lead to alternative or tangential methods.

"When a problem's effects are not directly observable, a community is likely to underestimate the risk posed by the effects."The damage of exposure to asbestos and radon are generally invisible, with problems appearing several decades after initial exposure. This is also true of orbital debris--neither the creators of the debris nor those who might be harmed by it can easily observe the potential threat.

The report recommends that stakeholders must continually reassess their situational awareness, use the Superfund as a model for orbital debris cleanup, and develop mitigation incentive structures for the short term. More broadly, it concludes that the space debris community will not be able to implement mitigation or remediation strategies until stakeholders agree on an acceptable level of risk tolerance.

Aviation Week Workforce Studies Released

August 30, 2011 — Vol. 4, Issue 6

The aerospace workforce saw more stability than change in 2011, according to two benchmark studies by *Aviation Week.*

In an effort to establish a single, credible source of information regarding the state of the workforce, *Aviation Week* conducted its annual Aerospace and Defense Workforce Study, which examined the corporate sector, and its second Young Professional Study, which evaluated young professional workforce across government and industry.

Aerospace and Defense Workforce Study

The industry has experienced a shift, with increased commercial opportunities and decreased government spending in the past three years. With programs maturing or ending, there have been numerous layoffs. How long this downsizing will continue is uncertain.

In a time of tight budgets, companies are placing a heavy emphasis on retaining talented employees. In addition to health benefits, they are offering pay raises and promotions exceeding those of the information technology sector and U.S. averages in general. This tradeoff is made at the expense of professional development opportunities.

Key findings include:

- Women make up one-quarter (24.7%) of the workforce, a number that has not changed much since 2000.
- The hiring forecast for 2011 is up from 19,000 in 2010 to 31,000 jobs. This is higher than the predictions for 2012 and 2013, which are forecast at 22,000 jobs openings per year.
- Base pay increased by 3.2% versus a national average of 2.5%.

The industry's impending retirement wave did not materialize this year. The average retirement age increased from 55-57 to 62 (reported by all but two organizations). Voluntary attrition rates for the general workforce have slowed, but young professional attrition rates remain higher than those for the general workforce. Young professionals (age 35 and under) comprised 22% of the workforce in 2010, down from 35% in 2000.

(Note: The data for the 2011 study reflect the 2010 calendar year.)

Thirty-two organizations participated in the corporate 2011 A&D workforce study, which represents 90% of the industry.

Young Professional Study

Eleven companies participated in the 2011 Young Professionals study. The population consisted of a 10% random sample of the workforce under the age of 35. Key findings included the following:

- 65% of the workforce is not looking for a new position at this time. Of those who are looking, 35% are searching within their organization, while 26% are job-seeking outside their current employer.
- Top factors in their career decisions are technological and intellectual challenge, benefits (e.g., health care, investment plans, advanced degrees, learning, and flexibility), location, and the opportunity to advance.
- The top frustrations are bureaucracy and politics. Over half believe that the pace of decision-making, progress, and management of change are not what they could or should be.
- Half (49%) plan to stay in the A&D industry until they retire.

A heavy emphasis on access to management, opportunities to for career growth, and a balance between life and work were identified as important.

The study found that three-quarters (76.6%) of respondents were white. Latinos (5.19%) and African-Americans (4.43%) accounted for just under one in ten of the survey population, and one-third (33.5%) of respondents were female.

This year also marks the first year of results from the longitudinal young professional study. Volunteers from the 2010 Young Professional Study participated. (The survey attracted a 30% response rate.)

Key findings include:

- 27% plan to stay with their current employer for ten years.
- 36% changed jobs in the past year.
- 44% were promoted.

The Young Professional Study was initiated in response to a three-year escalation of voluntary attrition among young professionals.

Aviation Week started the workforce study in 1997 and conducted the first Young Professional Study in 2010.

Chapter 9

This Month in NASA History

Reflections on *Challenger* by Bryan O'Connor

January 31, 2011 — Vol. 4, Issue 1

On the 25th anniversary of the *Challenger* accident, a story by Bryan O'Connor offers a powerful reflection on the dangers of organizational silence.

[Editor's note: The following is a transcript of a talk by Bryan O'Connor, NASA Chief Safety and Mission Assurance Officer, at Goddard Space Flight Center on July 30, 2009. O'Connor delivered his remarks at an event hosted by Goddard Chief Knowledge Officer Dr. Ed Rogers on the subject of organizational silence.]

When I first heard about this topic [of organizational silence], the very first memory that came to me was the flood of emotions after the *Challenger* accident. I lost some good friends in that accident. It had happened just two missions after I had flown my first spaceflight, so it touched me quite a bit there. I was already assigned to another mission, and that mission got delayed indefinitely and then later canceled as we went through post-flight/return to flight activities. Now I had lost friends before in aircraft accidents, but I had never had the same kind of feelings after those as I did after *Challenger*. And it wasn't just because I lost friends. There was another thing that entered the picture, and that was in spite of the fact that I didn't really have a job at NASA that put me in the accountability chain of command for safety on space shuttle, the fact is that I didn't know, like everybody else, I was responsible to some degree for safety—to the extent that I had any authority, to the extent that I had knowledge. I certainly had a responsibility to speak up if I didn't understand something. I kind of knew all of those things and I felt a little bit guilty. In fact, I felt very guilty. That was an overwhelming feeling that I had that I hadn't had in previous cases.

The U.S. flag in front of JSC's project management building flies at half-mast in memory of the STS 51-L crewmembers who lost their lives in the Challenger accident. Photo Credit: NASA/Johnson Space Center

The reason I felt guilty, I believe—and I've thought about it a lot since then—was that I could remember times when I was sitting in a meeting listening to a discussion in an all-pilot's meeting, maybe even over in a programmatic meeting, a change board or something—where I was sitting in the audience, where I thought and sometimes claimed to know that two people were talking past each other. And I didn't say anything about it. I just kind of let it happen. I thought, "Well, these people know what they're doing. The Space Shuttle Program comes from all this learning from Apollo. These folks can't really make mistakes because they have already done that, they learn from them and...this thing is being developed as something that will be pretty much an airline-like operation very soon here."

There were things about that whole concept that I didn't really get, I didn't understand. I remember having a discussion with T.K. Mattingly, who was training for STS-4, which as you remember, was going to be the last "test flight" for space shuttle and after that we were going to be "operational". STS-5 and beyond was operational. So operational, in fact, that they were going to put the pins in the ejection seats so that the crew couldn't use them on STS-5. And they weren't going to have ejection seats after that.

This, to me, was a huge leap of faith from my prior experience. I had come from an acquisition background where it took a couple thousand flights to get something to where it was IOC (initial operating capability), and then maybe another several hundred to full operational capability. And in DOD (Department of Defense) terms, IOC and FOC mean it's time to give it to the ultimate operator: we're done with all the testing, and it's time to go into the "operational phase" and give it to the operator to go use in the field. That's what those terms meant to me.

I saw us using terms like "we're going to be operational on Flight Five" on what looked like to me like a more complicated machine and operation than anything I'd ever been dealing with. And I asked Mattingly about it, and he said, "Don't worry about all that stuff, that's just rhetoric up in Washington. This thing will be in a test mode for a hundred flights." He told me that before STS-4. That was a little bit more comfortable to me because I thought, OK, I got it. I'm now in an area where there is a political and public affairs activity that goes on that I can't allow to interfere with my engineering and technical job. Yeah, I know they're taking the seats out, and I know we're going to put four or five people in these things, and there's people talking about flying reporters, book writers, teachers, and people who are not professional test-folks in a test environment, but I've got to treat that last part as just more rhetoric and that probably won't happen. Our people really understand the risks here.

Of course, there was a big awakening for all of us after *Challenger*. Those were thoughts that I had, and I didn't talk a whole lot about them. They just were just a way for me of rationalizing what was going on. But we didn't really talk much about that. We went the first twenty-some-odd flights—and this conversation between Mattingly and me was quite rare. It was almost as if we all know that but...let's just press on and do our business. When the *Challenger* accident happened, the accident board beat us up, the public wrote articles about how we were fooling ourselves about how operational we were, [and] we had totally under-estimated the risk of this operation. All those things that I had sensed at some point early on were now

Above: Crew members of mission STS-51-L stand in the White Room at Pad 39B following the end of the Terminal Countdown Demonstration Test. From left to right they are: Teacher in Space participant Christa McAuliffe, Payload Specialist Gregory Jarvis, Mission Specialist Judy Resnik, Commander Dick Scobee, Mission Specialist Ronald McNair, Pilot Michael Smith, and Mission Specialist Ellison Onizuka. Photo Credit: NASA

being blasted at us by the public. The same public that was buying our discussion about how safe this was, was now beating us up for how we had fooled ourselves. That was part of why I was feeling different after this accident.

In previous accidents, we weren't kidding ourselves about the risks, in any environment I had ever operated in. Flight test environment, training for combat, whatever, we kind of knew where we were, what the risks were, and yeah, bad things happen, that's too bad and we've got to learn from it. But we didn't come out of that thinking, "Wow, we really underestimated the risk there," like we did after *Challenger*. That, I think, was part of why I felt so bad. And how this feeling bad sort of registered was [the realization that] I'm never going to sit in a meeting and allow two people to talk past each other and not say something myself. Or at least talk to them in a hallway afterward. I just can't do that anymore. I don't have the right to do that. That was something I carried with me from then on.

There's a dilemma that goes with that, though, because that's an intimidating environment. When do you speak up and say, "I think you guys missed the point here?" I'm sitting in the peanut gallery and I'm not even cognizant of the technical issue here, it's just a matter of...trying to follow the logic and it doesn't make sense to me. I may not really know the details of the engineering discussion, but I can tell when two people are thinking they are agreeing on something and they didn't say the same thing. At least I know that. To that extent I am accountable because at least I know that, and I can say something about that. And I hadn't for five years. I sat and listened to that and I thought, 'Wow, sounds like those guys talked past each other, but I guess that's OK." It's not OK.

This was the big awakening for me after *Challenger*. I don't have the right to be quiet when I think something is wrong.

Now, what do you do about that? You could rapidly become a pain in the butt if you operated on every instinct. Even if you batted as well as Ted Williams and got four out of ten things right, six times out of ten you're a nuisance by speaking up and interrupting the flow of discussion and slowing things down and so on. That's real life. You have to take that into account. We can all say we all ought to speak up if we feel bad about something, walk out of here, and say, "Right, I'm going to do that." But in real life you've got to think about the environment you're really in. Do we really need to slow this thing down on this count? How badly do I actually feel about this? Is this something I can talk one-on-one in the hallway with? You've got to think about those things too, and that makes it more difficult sometimes.

Part of that awakening registered itself about three years after *Challenger*, when I was involved in the simulations out at Ames Research Center where they have this big vertical motion machine....It can get up about 80 feet above the ground and 60 or 70 feet left and right, 6 degrees of motion. We used it for landing simulations so we could try out new gains on the flight control system for landing and rollout, nose-wheel steering algorithms that we were trying to change to make it so that the space shuttle would be able to survive a blown tire on landing. [That was] one of the many things we were doing after Return to Flight. I was involved in that. I came back [to Washington] and I was sitting in a meeting where this was a topic of discussion, and Arnie Aldrich was program manager and he was in charge of this meeting. It was at a change board, and when this particular issue had come up, I was the guy they sent from the crew office to go sit and represent the crew office. I was sitting in there, but I'm sitting behind the chairman, not at the table. He went through everything, and they were talking about how they needed to make a change, and it was probably going to cost some money, and this will be to the benefit of the safety for the program. Arnie, somehow, was aware that I had walked in—I don't know how because I didn't say anything—but he turned around and said, "Now you just came back from Ames, right and flew the simulator?"

"Yes sir, I did."

"I want you to tell us about that."

I never would have volunteered what I had learned in that simulator in that meeting. I didn't have the nerve to break in, but I certainly had relevant information. The fact that the institution was such that they pulled something from me helped me with part of my dilemma about speaking up. It suggested that sometimes speaking up is not something that you can just tell every person that they have that right or that responsibility. It's something that you have to put into your organizational construct. You have to have a system that actually pulls a little bit. If you don't do that, you're going to miss a lot. Speaking up is not just about proactively interrupting meetings or raising your hand or throwing down the red flag. Those all have their place, but it's also about having a system in place that draws out relevant information, that gives people permission to speak, that points at folks and says, "What do you think?" When Arnie Aldrich did that, I thought, "That is tremendous leadership he just showed here," because I did have some relevant information that probably would not have gotten into this meeting had he not asked for it.

It showed two things to me. One, I'm still not there yet on when to volunteer. But two, it's really important to have an institutional component to this business of speaking up.

50th Anniversary of President Kennedy's Call for Moon Mission

May 10, 2011 — Vol. 4, Issue 3

On May 25, 1961, President Kennedy announced the goal of sending a human to the moon by the end of the decade.

President Kennedy's speech, delivered to a rare joint session of Congress, ignited the race to the Moon between the United States and the Soviet Union. It also set NASA on a course to develop the programs and missions that would lead to the Apollo 11 landing eight years and two months later.

Kennedy employed strong language to explain why he called for a joint session of Congress just months after delivering his first State of the Union address: "While this has traditionally been interpreted as an annual affair, this tradition has been broken in extraordinary times. These are extraordinary times. And we face an extraordinary challenge."

In a wide-ranging speech that addressed geopolitics, defense, and economics, Kennedy saved his dramatic announcement about the Moon mission until the end: "Now it is time to take longer strides—time for a great new American enterprise—time for this nation to take a clearly leading role in space achievement, which in many ways may hold the key to our future on earth."

President John F. Kennedy giving his historic message to a joint session of the Congress, on May 25, 1961. Photo Credit: NASA

After explaining the stakes and acknowledging the lead that the Soviets had in space, Kennedy spelled out the call to action:

> "First, I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the earth. No single space project in this period will be more impressive to mankind, or more important for the long-range exploration of space; and none will be so difficult or expensive to accomplish."

The conclusion of his remarks about space made clear that the Moon mission was a commitment on the part of all Americans, not just the President:

> "I believe we should go to the moon. But I think every citizen of this country as well as the Members of the Congress should consider the matter carefully in making their judgment, to which we have given attention over many weeks and months, because it is a heavy burden, and there is no sense in agreeing or desiring that the United States take an affirmative position in outer space, unless we are prepared to do the work and bear the burdens to make it successful. If we are not, we should decide today and this year.
>
> This decision demands a major national commitment of scientific and technical manpower, materiel and facilities, and the possibility of their diversion from other important activities where they are already thinly spread. It means a degree of dedication, organization and discipline which have not always characterized our research and development efforts. It means we cannot afford undue work stoppages, inflated costs of material or talent, wasteful interagency rivalries, or a high turnover of key personnel.
>
> New objectives and new money cannot solve these problems. They could in fact, aggravate them further--unless every scientist, every engineer, every serviceman, every technician, contractor, and civil servant gives his personal pledge that this nation will move forward, with the full speed of freedom, in the exciting adventure of space."

Kennedy also called for investments in nuclear rockets, communications satellites, and weather satellites. The investments in communications and Earth observation satellites helped establish the nation's foundational capability in these areas.

Surveyor 1 Lands Softly

June 14, 2011 — Vol. 4, Issue 4

Forty-five years ago this month, scientists let out a sigh of relief when Surveyor 1 didn't sink into the moon's dusty surface.

Until Surveyor 1 landed on the moon, it was anyone's best guess as to what the lunar surface was really like. In the mid-1950s, terrestrial telescopes couldn't resolve objects smaller than the U.S. Capitol. All kidding about green cheese aside, the prominent conjectures about its properties ranged from a deep layer of lunar dust (possibly electrostatic that would engulf alien objects upon contact) covering a labyrinth of hidden crevasses to a meteoroid-battered surface resembling a World War I battlefield. If NASA wanted to land men on the moon, it needed to do some groundwork.

Surveyor: The Spacecraft

"Few space projects short of Apollo itself embodied the technological audacity of Surveyor," wrote Edgar Cortright, former director at Langley Research Center, in Scouting the Moon. Problems cropped up early in the project. Technical problems caused the schedule to slip, cost to grow, and mass requirement to increase.

Formally approved in the spring of 1960, the Surveyor Program intended to investigate the lunar surface and to inform NASA engineers what they would encounter when landing a spacecraft and crew on the moon. The program would demonstrate the technology needed for landing on the lunar surface, inform the Apollo design, and add to the overall knowledge of the moon. Concurrently, the Ranger and Lunar Orbiter programs worked towards imaging and mapping the lunar surface to provide options for landing sites.

Surveyor was equipped with throttleable retrorockets to guide the nearly 2,200-pound spacecraft to the lunar surface. Surveyor 1 carried little in the way of scientific equipment, but had two television cameras, one of which was not used. Later Surveyor missions were designed to carry a single television camera and 350 pounds of scientific instruments. The spacecraft consisted of a triangular framework of aluminum tubes about ten feet high. Three honey-combed footpads supported the craft with a solar array and antenna.
The Jet Propulsion Laboratory oversaw the Surveyor spacecraft development, with Hughes Aircraft Company serving as the prime contractor. When cost, schedule, and mass challenges arose, JPL and Hughes reorganized their groups to improve the development and testing phases of the spacecraft.

"If we can pull this off, the American people have reason to be really proud, because this is no mean technical feat, believe me," Surveyor Program Manager Benjamin Milwitzky told the *New York Times*.

Centaur: Surveyor's Ride

Surveyor's ride to the moon was the Atlas-Centaur rocket. The Centaur upper stage was the first hydrogen-fueled rocket in the world. Devised in 1956 by a General Dynamics engineer, the Centaur had its origins in a collaboration between the Advanced Research Projects Agency (ARPA) and the U.S. Air Force. NASA took ARPA's place in the partnership in 1959, giving management of the project to Marshall Space Flight Center. But it turned out that Marshall, busy with the development of the Saturn rockets, was unable to give the Centaur program the attention it needed. NASA reassigned Centaur management to the Lewis Research Center (now Glenn Research Center) in 1962.

In addition to management troubles, the Centaur program had technical challenges as well: cracks in the liquid hydrogen fuel tank common bulkhead face sheet, unstable weather shield structure, and a dwindling payload weight capability. Abe Silverstein, the program manager at Lewis, did manage to turn things around, but at the expense of increasing the budget by nearly six times the original projection.

The Centaur, initially slated to carry a 2,500-pound payload, fell to 1,800 pounds. Silverstein and his group managed to get the payload weight up to 2,150 pounds, but the vehicle was still overweight.

Testing the Centaur included its share of successes, engine failures, and explosions. A fifth test of the AC rocket, which carried a Surveyor dynamic mass model, resulted in one of the biggest explosions ever seen on a Cape Canaveral launch pad. The pad had to be rebuilt, along with the development of another pad next to it, to meet the Surveyor Program's schedule.

Lift-off and Landing

Surveyor 1 launched on May 31, 1966, beginning its three-day journey to the moon. No one knew if this first attempt would actually work. In a 1966 ***New York Times*** **story** about the launch, Clark Evert wrote, "It was, to follow Milwitzky's analogy, like a first night for a symphony musicians who had a new director, had not rehearsed together, and did not know the acoustics of the hall."

Six hundred pounds when it landed in the Ocean of Storms on June 2, 1966, Surveyor 1 started to send home images that would confirm that it was safe to land on the moon. The camera transmitted back images with a resolution of up to 2 millimeters. Cortright recalled the landing from the control room at JPL. "We sat up most of the night watching the first of the 11,240 pictures that Surveyor 1 was to transmit."

Televised pictures of the spacecraft's footpad depression put NASA at ease. The moon would not engulf NASA's astronauts after all. These images, showing the barren, cratered, rocky surface of the moon we are familiar with today, also demonstrated that the lunar surface could support a larger spacecraft and crew.

Surveyor 1 operated until January 7, 1967. Two of the six Surveyor spacecraft that followed failed to reach the moon successfully. The remaining four carried cameras and scientific instruments to the lunar surface that informed the Apollo Program right up until the last transmission of the Surveyor 7 spacecraft in 1968.

GENESIS LAUNCHES

August 30, 2011 — Vol. 4, Issue 6

Ten years ago this month, Genesis launched to discover the origin of our solar system. Three years later, it had an unexpectedly rough return in the Utah desert.

On August 8, 2001, the Genesis spacecraft launched aboard a Delta II rocket from Cape Canaveral on a million-mile journey to its orbit at Lagrangian-1. The fifth Discovery mission, it was to provide a better understanding of the formation of the solar system. Flying just outside the Earth's magnetosphere, Genesis captured samples of solar wind that would later be returned to Earth and analyzed for their chemical and isotopic composition. The spacecraft was equipped with ion and electron solar-wind monitors and an electrostatic mirror.

The Jet Propulsion Laboratory (JPL) in Pasadena, California managed the project. The California Institute of Technology provided the principal investigator and project team lead. Lockheed Martin provided the spacecraft and the sample return capsule.

Resembling an "unbuckled wristwatch" while on orbit, the Genesis spacecraft closed up on April 1, 2004, and after 28 months headed for home. The entry, descent, and landing profile for the mission involved the capsule entering the atmosphere with a parachute system slowing its fall to the ground—only the parachute never deployed.

The Genesis capsule plummeted into the Utah desert at 193 miles per hour.

While technically not a failed mission because the mission samples were still intact, the return was categorized as a formal mishap. NASA Chief Engineer Michael Ryschkewitsch, leader of the Genesis Mishap Investigation Board, reflected on his experience:

Your first reaction when you see a mishap is "Boy, must be some sloppy incompetent folks that did that." What you learn in a heartbeat is that there are a lot of very high-quality

The Genesis sample return capsule crash-landing in the Utah desert. Photo Credit: NASA organizations that at some level, either simply made some little mistake or got lulled into some complacence along the way and it had disastrous consequence. But the more important thing you learn is that you are not as good as you think you are. Working through Genesis, I think every mistake that was made there I had seen someplace in some project that I had worked on. There had been enough other checks and balances and safety nets so that we'd never had a disaster like that. But I had seen every attribute in that. And having read a whole bunch of other mishap reports, you see the same kinds of thing happening again. I think one of the things we probably need to do a better job of is getting more people onto mishap teams and reading mishap reports and seeing what is out there. There is such a tiny fine line between success and failure in this business.

The mishap investigation board concluded that the proximate (or direct) cause of the Genesis mishap was an acceleration-sensitive sensor called a G-switch. Normally, a plunger in the sensor responds to the buildup of g forces as the capsule moves through the atmosphere. The plunger makes electrical contact at the end of the sensor, closes the circuit, and arms a sequencer. When the g forces lessen, the plunger moves away, breaks contact with the end of the sensor, and starts the sequencer.

In the case of Genesis, the sensor, no larger than a metal eraser holder on a standard No. 2 pencil, was installed upside down. The G-switch never responded to the g forces. According to the mishap report, the problem was inherent in the design process. The design reviews didn't catch it, the verification process didn't catch it, and the Red Team review process didn't catch it.

The board identified six root causes for the mishap:

- Inadequate project and systems engineering management
- Inadequate systems engineering processes
- Inadequate review process
- Unfounded confidence in heritage design
- Failure to "test as you fly"
- Faster, better, cheaper philosophy

Despite the mishap, the Genesis mission samples were successfully recovered and have been providing insight into the formation of the solar system.

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